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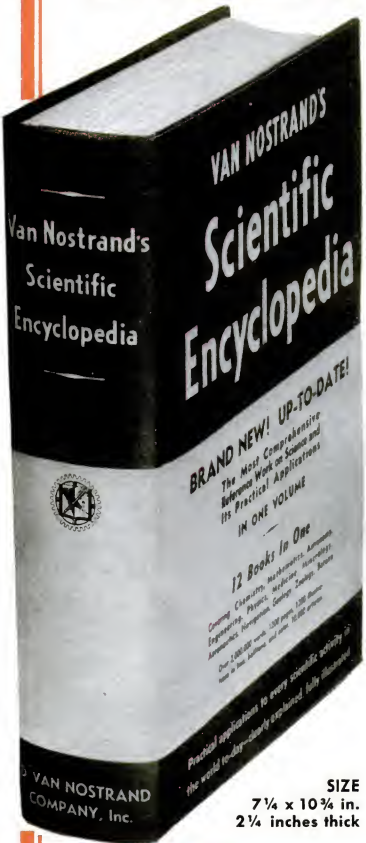

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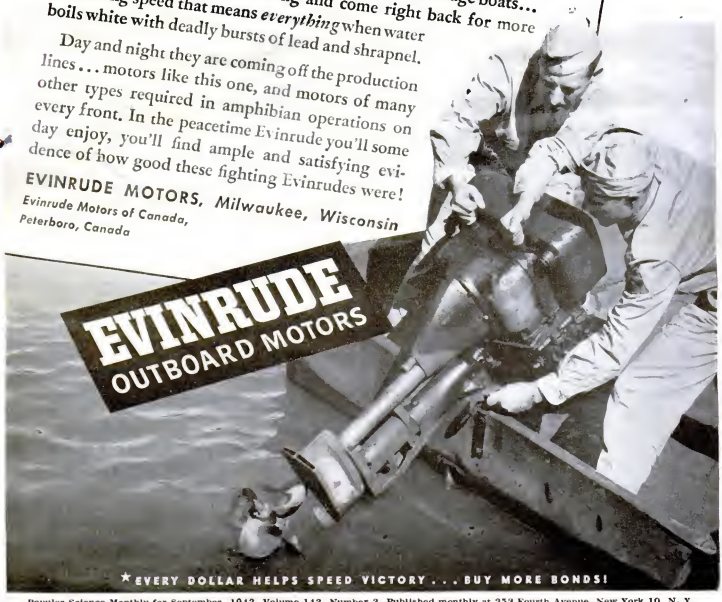

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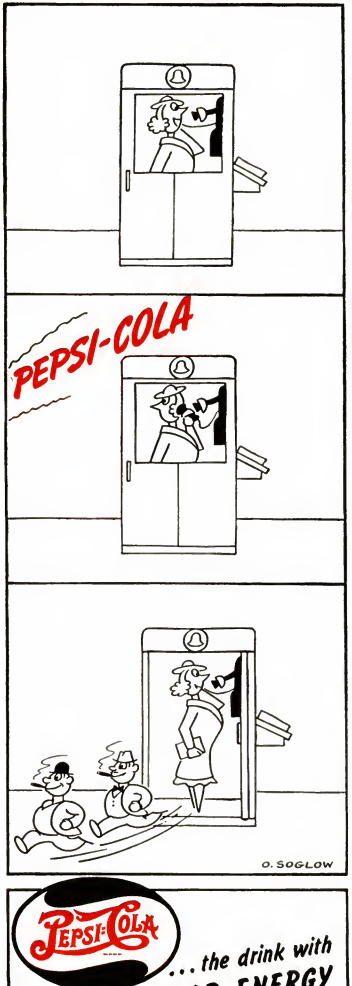

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There's a big shortage of capable Radio Technicians and Operators. Fixing Radios pays better now than for years. With new Radios

Set Servicing pays many N.R.I. trained Radio Technicians $50 a week. Others hold their regular jobs and make $5 to $10 extra a week fixing Radios in spare time.

out of production, fixing old sets, which were formerly traded in, adds greatly to the normal number of servicing jobs.

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Many Beginners Soon Make $5, $10 a Week Extra in Spare Time

There's probably an opportunity right in your neighborhood to make money in spare time fixing

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"Am with the Civil Aeronautics Administration as Aircraft communicator at the Shreveport Airways Communication station. Have a lifetime position, with pension after retirement."—JESSE N. ROBERTS

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"I cannot divulge any information as to my type of work, but I can say that N.R.I. training is certainly coming in mighty handy these days."—LIEUTENANT RICHARD W. ANDERSON.

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"I was working in a garage when I enrolled with N.R.I. I am now Radio Service Manager for M— Furniture Co. for their 4 stores."—JAMES E. RYAN

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Radios. I'll give you the training that has started hundreds of N.R.I. students making $5, $10 a week extra within a few months after enrolling. The N.R.I. Course isn't something just prepared to take advantage of the present market for technical books and courses. It has been tried, tested, developed, perfected during the 28 years we have been teaching Radio.

A Great School Helps You Toward the Rich Rewards in Radio

Throughout your training, the staff and resources of the world's largest private home study institution devoted entirely to training men for Radio will be squarely behind you. N.R.I. has stuck to the one job of teaching Radio for 28 years. Our combined efforts have made the Course so interesting, with hundreds of pictures, charts, and diagrams, and with special teaching methods designed especially for home study—that we believe you will be "old friends" with Radio almost before you know it.

Broadcasting Stations employ N.R.I. trained Radio Technicians as operators, installation, maintenance men and in other capacities and pay well.

Here Are Just a Few of The Subjects This Lesson Covers 31 PHOTOS, CHARTS, DRAWINGS

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How to remove tubes, tube shields
Three reasons why radio tubes fail
Electrodynamic loudspeaker:
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Replacing damaged cone
Recentering voice coil
Remedies for open field coil
Output transformer construction, repair
Gang tuning condenser:
Construction of rotor, stator
How capacity varies
Restringing dial cord
Straightening bent rotor plates
I. F. transformers—What they do, repair hints
How to locate defective soldered joints
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Paper, electrolytic, mica, trimmer condensers
How condensers become shorted, leaky
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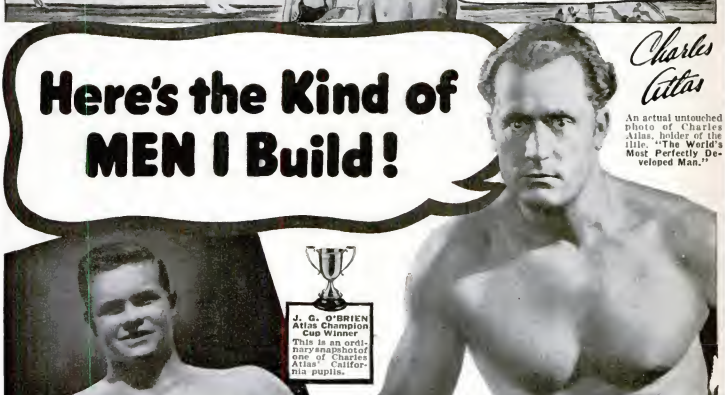

Will You Let Me PROVE I Can Make YOU a New Man?

I DON'T care how old or young you are, or how ashamed of your present physical condition you may be. If you can simply raise your arm and flex it I can add SOLID MUSCLE to your biceps—yes, on each arm—in double-quick time! Only 15 minutes a day—right in your own home—is all the time I ask of you! And there's no cost if I fail.

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"Dynamic Tension!" That's the ticket! The *identical natural* method that I myself developed to change my body from the scrawny, skinny-chested weakling I was at 17 to my present super-man physique! Thousands of other fellows are becoming marvelous physical specimens—*my way*. I give you *no gadgets or contraptions to fool with.* When you have learned to develop your strength through *"Dynamic Tension"* you can laugh at *artificial* muscle-makers. You simply utilize the DORMANT muscle-power in your own God-given body—watch it increase and multiply double-quick into real, solid LIVE MUSCLE.

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(Please print or write plainly.)

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☐ Check here if under 16, for Booklet A.

If he could only see me Now!

There's one guy back in Florida who would get just as big a bang out of this as I do—my first instructor. And in a way, he got the Zero, not me. I wouldn't have been up there in the sun when they came over this morning if he hadn't had the confidence and patience during those first hours. Sometimes I think the primary instructors are the guys that are really winning the War.

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SPIES are at work in our midst, trying to help our enemies with reports on our arms production, convoys, and troop movements. Against them are pitted the best brains of the FBI. Arthur Grahame brings you the thrilling story of this deadly battle of wits, in which modern scientific methods are mingled with the time-honored tricks of the secret agent.

GOING UP! Ceilings for aircraft operation have been pushed upward by the war. Now, aviation men are looking ahead toward commerical flying at the 50,000-foot level when peace comes. William S. Friedman discusses the problems of high-altitude flying and tells how experimenters are blazing the trail for the sky liners that will navigate the stratosphere tomorrow.

INSECTS offer fascinating subjects for your camera. All about you in summer are fantastic faces and figures, waiting to be recorded on film. Your guide to this inviting field of photography is Edwin Way Teale, whose insect pictures in newspapers, magazines, and books have won him top rank in his field. He tells you how to do it with ordinary equipment, and illustrates his advice with his own inimitable work.

DON'T SNEER AT THE FILE. This humble tool, sometimes treated as the stepchild of the machine shop, is playing a big part in war production. You will find a lot of things you didn't know about files—how they are made, what kinds there are, and how to take care of them—in an article by Jean Ackermann. Since there are over 3,000 specialized types of files in use, the subject is no small one.

PLANET OF MYSTERY. Mars, Earth's closest kinsman in the solar system, has always fascinated men. Because its climatic conditions approach those of our own planet, we suspect that it may be peopled by creatures like ourselves; strange markings on its face suggest canals or other artificial works. What are the latest views of science on this perennially attractive theme? A distinguished astronomer brings you up to date on the mystery of Mars.

IT WILL SOON BE TIME to lay up your boat for the winter. And right there is a place where the proverbial stitch in time saves plenty. Let J. A. Emmett show you how to make the small repairs and take the precautions that will lengthen the life of your boat and save you expensive jobs later on.

MEN! *Learn* ELECTRICITY *whether you are* 16 OR UP TO 50

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DON'T BE HELD BACK BY:

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See the "oldster" in this picture! Men like him can have a real future in Electricity. It isn't how **young or old you are**, it's what you KNOW, that counts!

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It is not necessary that you be a high school graduate, to take my training. Coyne instructors know how to explain each step in an easy, understandable way.

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I'LL FINANCE YOUR TRAINING!

Don't wait to be assigned to some dull, low-pay, no-future job! Get your training at Coyne NOW — and be ready **soon** to take your pick of many well-paid electrical positions.

Learn to do more vital work for America's war program. In 12 short, busy weeks in the Coyne Shops you can get the "know-how" you need for a real opportunity now — **and at the same time you'll be in a field with a peace-time future.**

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Coyne has a vast amount of floor space in shops where you learn on motors, switchboards, electronic devices, air conditioning and refrigeration apparatus, auto and aircraft engines. You also learn house wiring, motor wiring, armature winding, etc., etc.

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As soon as you're trained, my Graduate Employment Service will assist you in getting located. This service is FREE to graduates. We have placed men in fine jobs all over America. You'll find this service a big help now and throughout your lifetime.

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NAME.....

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Readers Say:

Here's the Wright Dope on Early Airplane Engines

In a recent issue you make the statement that the engine made by the Wright brothers was the first engine powerful enough and light enough to permit sustained flight. I would therefore like to call your attention to the fact that when the Wrights designed and built their engine, there already existed a better engine, designed and built in 1901 by Charles M. Manley, who at the time was also working on the problem of flight. Let me hasten to explain that I have no intention of belittling the work of the Wright brothers. Despite that they were not engine designers, they were successful in building their engine even after automotive engineers had told them that such an engine was impossible.

Manley's engine was a five-cylinder, water-cooled, radial type of five-inch bore, with a 5½-inch stroke, and 539.96-cubic-inch displacement. It developed 52.4 hp. at 950 r.p.m., and its total weight, including radiator, gasoline tanks, and water, was 192 pounds—or 3.66 pounds per horsepower.

The Wrights' engine, built in 1903, was a four-cylinder in-line type of four-inch bore and stroke. It developed 12 hp. at 1020 r.p.m., and, complete with radiator, tanks, water, and fuel, it weighed 200 pounds—or 16.66 pounds per horsepower. For the first few moments of its life it developed 16 horsepower, but when finally installed in the plane, it gave only 12.—C. E. St. J., Honolulu, T. H.

Two Good Puffs for the Chest-Inflation Dept.

In today's paper there is a news item that our Army Air Forces have accepted a new type of portable radio which sends sustained distress signals. The aerial is held aloft by a kite. In the April issue of your magazine, which I received a couple of months ago, this same radio is described in full on pages 94-95. A few weeks ago, the newspapers published the "startling" news that one of Great Britain's secret weapons consists of a shell which, after it has been fired, floats down on a parachute, entangling enemy planes in its dangling wires and forcing them down. On page 111 of your May, 1940, issue, this "new" weapon is described in full. These are but two of many instances in which I find that P.S.M. has "scooped" the newspapers. Keep up the good work.—D. M., Brooklyn, N. Y.

How To Give a Sucker a Break

In one of your recent articles there arose the question of how to pour water into an aquarium without disturbing the contents. A good way is to lower the bottom of a net slightly below the surface of the water and then pour the fresh water into the net. I find this is a lot easier on the poor fish.—D. B., Webster Groves, Mo.

He Puts a Ceiling on Ciphers

In connection with your recently published article, "Pellets of Power," there appears the statement—"that the number of vagrant electrons in a cubic inch of copper wire is 15×10^{23}—ten followed by 23 ciphers." This is incorrect. Ten to the 23rd power is 10 followed by 22 ciphers, or one followed by 23 ciphers.—D. R., Lansing, Mich.

You're quite right, D. R. Thank you for calling it to our attention, and for giving us an opportunity to make this belated acknowledgment for the benefit of those readers who might have found themselves burdened down with one too many ciphers.—Ed.

A New Industry Comes Out of the Woods

Plywood, the structural material of the future, takes to the skies today. Planes of many types are now being made of plywood, superior in certain characteristics even to fine steel or aluminum.

With war-time expansion of plane production, Fairchild foresaw shortages in the light metals. Research and engineering development of plywood at Fairchild were given a great stimulus. New data and new techniques were developed, made possible by recently perfected adhesives. Plywood craftsmanship jumped ahead many years in a few short months.

By a patented Fairchild process, known as DURAMOLD, layer-on-layer of wood, laid cross-grain and permanently joined with special resins under heat and pressure, may now be molded into single and multi-curved structural surfaces of consistently high quality.

DURAMOLD possesses some distinct advantages over metal aircraft surfaces. It is more fire-resistant. It makes lighter, stronger planes; the rigid DURAMOLD shell is its own support, eliminating the need for a great clutter of internal stiffeners, bulkheads, and other reinforcing members necessary in thin metal construction. It does not wrinkle nor buckle in the airstream, as does a metal surface. There are no non-flush rivets, as no rivets are required. Thus, it is *smoother* in the air . . . horsepower is not handicapped by increased "drag." The plane can fly faster, is more maneuverable and has greater lift and range in the field of high-speed performance.

Production of DURAMOLD structures in spars, flat pieces, and complex curved surfaces is now concentrated within the aviation industry. Its purposes are 100% the purposes of war. But, when victory is won, the techniques, facilities and craftsmanship of a new industry can and will be applied to a multitude of peace-time products.

DURAMOLD, another example of those Fairchild achievements which put the "touch of tomorrow in the planes of today," is available to all "priority" manufacturers. Write for free illustrated booklet.

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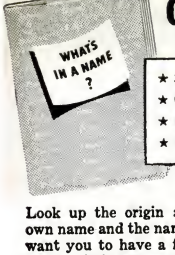

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for DESIGNERS INVENTORS DRAFTSMEN

Readers Say:

He'll Drive His Bathtub Water Crazy

To P. W. M. whose letter appeared in the July issue, and who states that the water that leaves the bathtub on Saturday night usually has a tendency to whirl counterclockwise, I say BALONEY! Many's the time I've reversed the direction of the whirl—whether it was clockwise or counterclockwise—merely by spinning my hand in it the opposite way. In fact, I changed the direction of one whirl so often, and got the water so dizzy, that it tried to escape by climbing up over the edge of the bathtub. I also want to say that the reason a dog makes several turns before lying down is that, having spent the day going around in circles chasing cats, birds, and postmen, he naturally wants to unwind before he goes to bed. So he takes a few turns in the *opposite* direction.—M. L. H., Levering, Mich.

Anyone Got a Better Recipe for Pi?

HERE IS something that has been puzzling me for quite a while—and I'm wondering if you know the answer. When, where, and how was Pi (3.1416159) first brought into use, and to how many places may it be carried out? I believe that a lot of readers would be glad to know the answers to these questions. —J. M., St. Louis, Mo.

According to our best information, Pi (3.14159265359) has been carried out to 707 decimal places by a W. Shanks, whose work recently appeared in a French scientific journal. It can, however, be carried out indefinitely. In the computing of Pi, two polygonal figures have been used; one inscribing a circle, the other circumscribing it—the mean length of the two then being taken as the perimeter of the circle. The first use of Pi probably dates back to the days when Archimedes took to running naked through the streets of Syracuse shouting "Eureka" over his now famous law of displacement.—Ed.

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Color and condition tell if plugs are operating properly. Matching your plugs with those illustrated on the "Plug-Chek" is the first step in getting new life for "spark-weary" engines.

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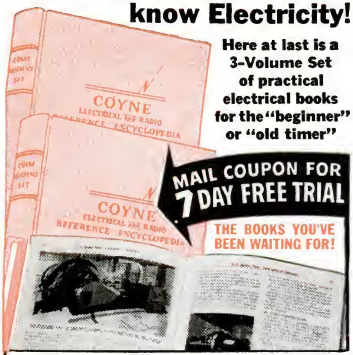

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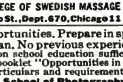

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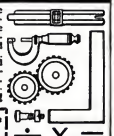

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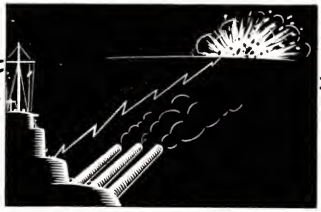

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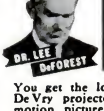

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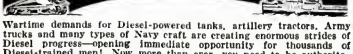

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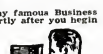

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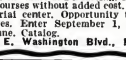

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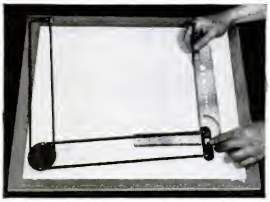

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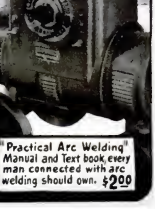

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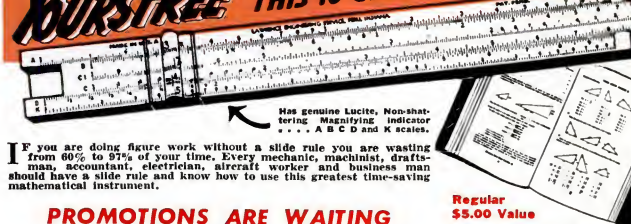

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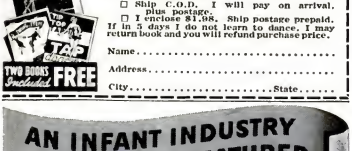

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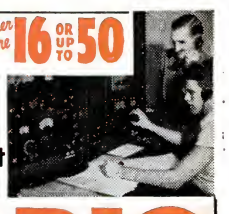

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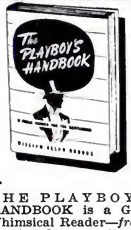

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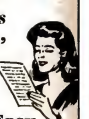

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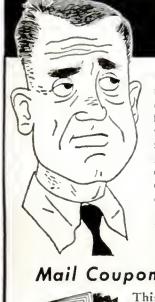

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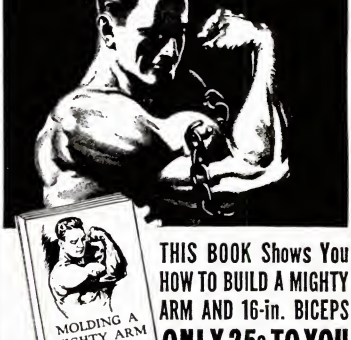

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SONGWRITERS: Write for free booklet, Profit Sharing Plan. Allied Music Company, 204 East Fourth, Cincinnati, Ohio.

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SONGWRITERS, Melodies Written to Poems. Send Poems, "Popular Songwriters", Martins Creek, Pa.

SONGWRITERS—Free Book. Send Poems. Variety, Dept. 3, Salem, Indiana.

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SWAP Guns and Ammunition with Klein's and get Cash. We pay More—you pay Less, because we're America's best known, biggest traders. Thousands upon thousands of new and used Guns from $5—up to the finest. All models, gauges, calibers, makes: Winchester, Remington, Colt, Savage, Smith & Wesson, etc. We also buy, sell or trade Ammunition, Fishing Tackle, Outboards, Golf Equipment, Binoculars, Cameras, Watches. Description, price you have to trade or sell for cash. Special! Ferrine "Magic Circle" sight for shotguns. (State model, gauge, barrel length of barrel.) Postpaid $1. "Money Back Guarantee" backed by 56 years' fair dealing. Free "Guaranteed Bargain Catalog" featuring thousands of "Hard-to-get" items; send dime (returned with first order) to cover handling costs. Klein's Sporting Goods, Milton Klein, Pres., 506J South Halsted, Chicago.

BOWS-Arrows for Recreation-Hunting-Fishing. Beautiful Archery instruction book, 90 pages, 50 illustrations, only 50c. Illustrated catalogue Free. Archery, 617 South State, Chicago.

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SEND for free illustrated catalog of Lawrence leather belts, holsters, gun cases and other sporting goods items. Lawrence Lawrence Company, Portland, Oregon.

276 ANTIQUE Firearms, Swords, Cartridges, Rifles, Indian Relics. Catalog, 10c. (Photographs of Most) Helke, Wenona, Ill.

GUN Smithing antique and modern. Joseph Gravitter, 712B West Blodgett St., Marshfield, Wisconsin.

ARCHERY Equipment: Catalogue Free. Mid-West Archery, 2209-D East 75th, Chicago.

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500 UNITED States for 10c! 500 U.S.A.—absolutely unpicked and unsorted—just as received from the mission stations. Many varieties, including commemoratives, airmails, high values up to $5.00 denomination! Price only 10c to approval applicants! Money back if not delighted, Swan Stamp Co., Dept. 69A, Dunkirk, N. Y.

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FINE Approvals, freshly mounted. Fast, personal service. Tell me what countries you prefer and I'll send their stamps. Milton Skinner, 345 East Ocean, Long Beach, Calif.

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FREE!!! British Empire Packet. Postage 3c. Williams, 601 Archerbldg., Baycity, Mich.

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50 FREE, pictorial etc., stamp dictionary, list. Bullard, Newcastle, Me.

PENNY Approvals that satisfy. Neil Gronberg, Box 5441S, Philadelphia 43, Penn.

1000 MIXED U. S. Old and New 25c, 2 lbs. $1.00. Weatherby, Troy, Ohio.

300 STAMPS—10c to approval applicants. Fair, Box 780, Bristow, Oklahoma.

MODERATE Cost Approvals. Reference. Wilson, 2999 East Blvd., Cleveland, Ohio.

UNITED STATES Stamps on approvals. Large stock. Box 488A, Minneapolis.

400 DIFFERENT stamps $1.00. No approvals. N. Greenstreet, Port Angeles, Wash.

TOBACCO—PIPES

IMPORTED Briar Pipes. No putty, plugs or clay fills. No stain or varnish. Genuine Imported Virgin Briar. Excellent quality. Only $1.75. Send for free catalog and trial offer. Sidney Ram, 59 West Monroe, P4, Chicago, Illinois.

FREE To Pipe Smokers—For a new pipe smoking thrill and experience, tell us your brand of tobacco and get Free pack age Mild, Cool, Nature-Flavored "Green River". Write today. Pete Moberly, Box 964, Owensboro, Ky.

TRAPPING

FOXES, Nine in one day. Trap all furbearers. Particulars Free. Guaranteed. Write—Estabrook, Sherburne, Vermont.

WANTED—MISCELLANEOUS

WANTED: 1930, V-16 Cadillac. Convertible sedan or cabriolet. Must be in good condition. Dix Griesemer, Lakemills, Iowa.

ACCORDION—any condition. Give description, price. Chaton, 600 Blue Island, Chicago.

CUTBOARD Motors, any condition. Write for cash price. Asa Gallupe, Fort Fairfield, Maine.

CASH for used optical, mechanical, scientific Instruments. Gordon's, 162-SB Madison, Chicago.

MERCURY (Quicksilver) we pay $1.50 per pound. Western Metal Co., Bloomington, Illinois.

WELDING, SOLDERING

NEW model electric welder 110 volt AC-DC; will weld all metals; easy to use; full directions complete with power cord, flux and metallic arc attachments, carbons, fluxes, rods, mask; all for $19.95—Used by the Navy. Marvel Electric Welder Mfg. Co., 195-AV Center St., New York City.

BUILD a.c. arcwelder without rewinding armature. Parts $1.00 each. 25 to 600 amperes from Vehicle motors. Light plant generators. Automobile starter-generators. Welders Club, WB-3432 M-Mart, Chicago 54.

FORGEWELD, White metal rod (Welds diecast parts). All purpose brazing flux, arc welding rod coating. All three, $1.00. Philip Wilson, 1341A E. St., Napa, Calif.

WELD, Cut, Braze with gasoline! New discovery. Make your own torch. Instructions one American dollar. Matthews Mfg. Co., Calgary, Canada.

What goes on under a Nazi pilot's cap?

PUT YOURSELF IN HIS PLACE . . . in his cockpit climbing swiftly away from an Axis airfield into a pitch-black night . . . bomb racks loaded . . . heading for Yank-held territory.

How would your mind work (under a Nazi bonnet), if you knew Radar's sleepless, X-ray "eyes" were waiting up to greet you . . . on warships, airfields, and lookout posts of the United Nations' forces?

What would you be thinking . . . knowing that Radar was robbing you of "surprise", the attacker's one tactical advantage . . . detecting you as much as 130 miles from your target? *Always* watching you . . . in storm, clouds, and fog . . . five miles up or skimming the waves! . . . *marking you for ambush and destruction!*

When the flak whams accurately through the clouds to rip jagged wing holes; when you meet night fighters who need no flame from your exhausts for true aiming, wouldn't you momentarily doubt the infallibility of the "master race"?

Wouldn't you nurse a scowling respect for American ingenuity? For Radar was developed in the United States . . . pretty much the product of Navy and Army research laboratories who weren't as unprepared as you thought.

And shouldn't it occur to you that a fellow can't win when he's fighting against a nation with the inventiveness and resources to produce weapons like this?

Westinghouse Electric & Manufacturing Company, Pittsburgh, Pennsylvania.

Westinghouse was making Radar 18 months before Pearl Harbor. Since then, Westinghouse production of radio communications equipment, including Radar, has increased 41 times!

Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

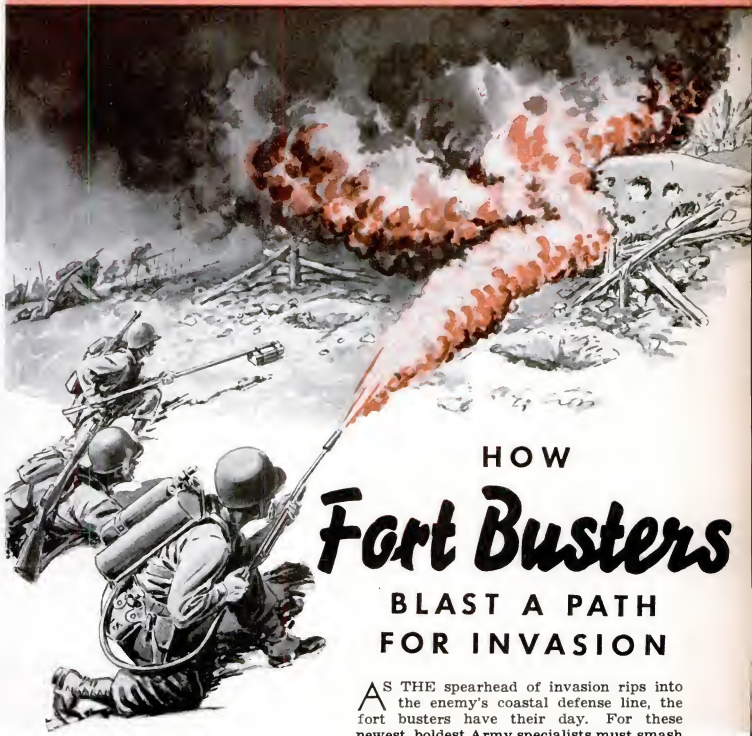
Famous dates in the history of Radar

1922. Naval Laboratory, Anacostia, D. C. Dr. A. Hoyt Taylor and Leo C. Young, observing that radio signals were reflected by passing ships, saw in it a means of detecting enemy vessels in darkness and fog. This was the birth of Radar!

1937. Bloomfield, N. J. Westinghouse developed the key electronic tube for the U. S. Army's *first* Radar equipment used to detect aircraft. Radar focuses invisible, ultra-high-frequency waves traveling at 186,000 miles per second.

1941. Pearl Harbor, T. H. Approaching Jap bombers were detected by a Westinghouse-made Radar when 132 miles distant. Because a flight of American planes was expected, no warning was sounded. Today, on every front, Radar has revolutionized naval and air battle tactics . . . multiplied a hundredfold the range of human vision.

Can We Crack Hitler's Defenses?



HOW Fort Busters BLAST A PATH FOR INVASION

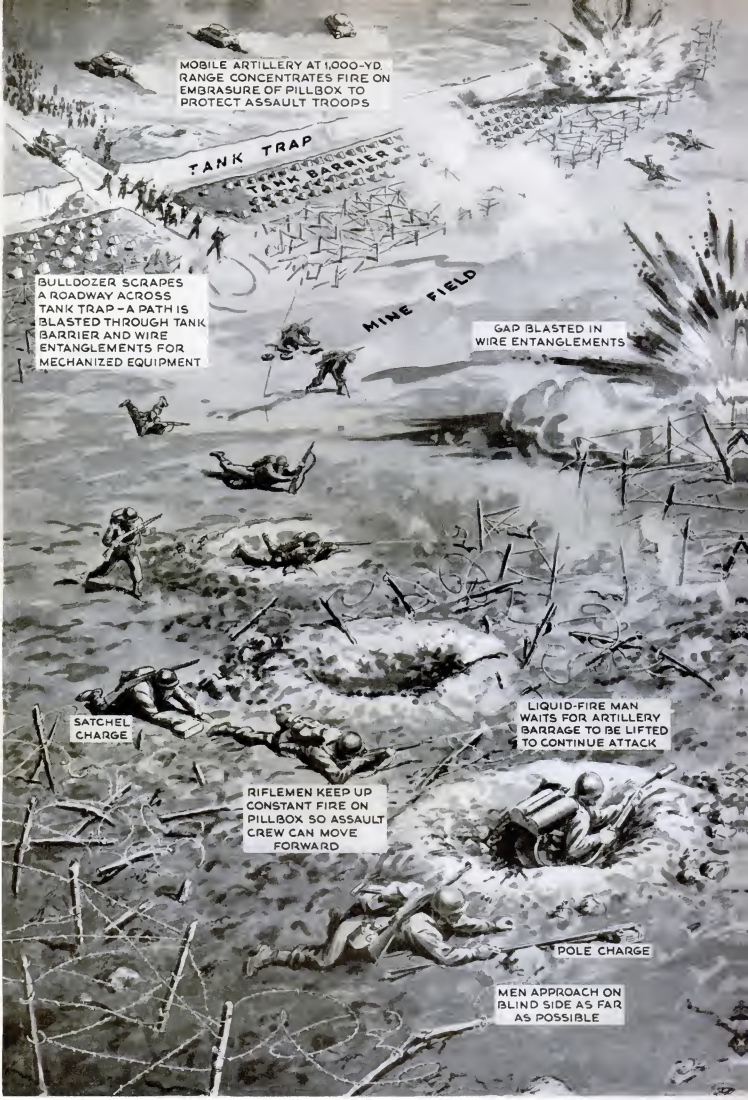
The Axis European fortifications may be a hard nut to crack, but our Army demolition men have the answer in TNT, flame, and courage.

By JACK O'BRINE

Drawings by B. G. SEIELSTAD

AS THE spearhead of invasion rips into the enemy's coastal defense line, the fort busters have their day. For these newest, boldest Army specialists must smash the greatest of all military obstacles—the shell-belching strongholds of cold steel and concrete that guard city approaches and stud countrysides in deadly, defiant patterns of defense. To reach their objectives, these demolition wizards of the combat engineers worm their way under enemy fire, slashing through barbed-wire entanglements, blasting tank traps, and ridding their path of treacherous, concealed land mines. Their chief equipment: TNT, flame throwers, and courage.

When the fort busters begin to move, you can be sure the enemy is in for a bad time. Their "go" sign is a combined assault in which the region is *(Continued on page 52)*

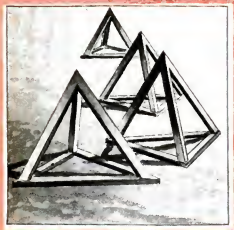


Fort Busters in Action: How Combat Engineers Reduce an Enemy Strong Point

and Clear the Way for Mechanized Equipment and the Supporting Infantry

DRAGON'S TEETH are blocks of steel and concrete set in jagged rows to stop attacking tanks

TANK BLOCKADES, with shafts of steel firmly braced against approach, also ring Nazi defenses



TETRAHEDRONS, pyramidlike skeletons of steel, are scattered freely in the path of attackers

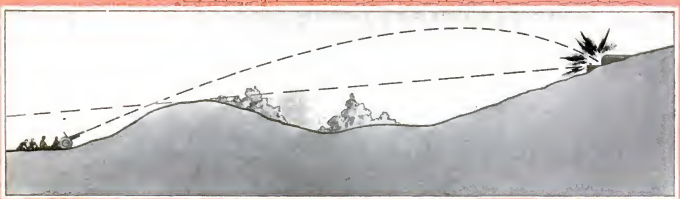
"JACKS" are giant versions of the pieces used in the children's game. They make trouble for tanks

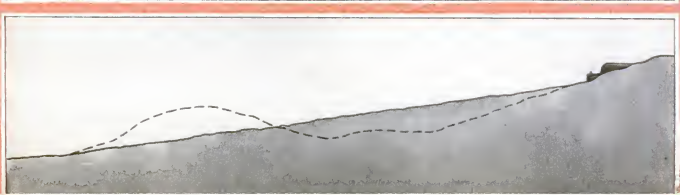
pummeled by heavy artillery and aerial bombardment. This has a triple purpose: to neutralize enemy fire, to strip the fortifications of camouflage, and to open in the terrain places of concealment for the attackers. Experience has proved that well-built bunkers, pillboxes, and blockhouses can withstand a terrific pounding. So actual damage is likely to be small.

Soon this aero-artillery prelude clears the way for use of the direct-fire guns, the 155's, the 105's, the three-inchers, the 75's, and the 37's. As the demolition squad slithers forward, these mobile fieldpieces open up and begin slamming steel and explosives at the embrasures. Bunker crews must close steel doors to prevent serious damage. This reduces enemy machine-gun fire to a minimum, and the engineers increase their pace, now and again leaping up from their belly crawl and running a few yards.

It's a strange task force. Uniforms are nowhere in evidence. Camouflaged coveralls speckle the ground. Weapons are chosen for the particular job in hand. On the backs of several men are the big cylindrical tanks of flame throwers. Others carry six-foot sections of pipe loaded with TNT. Used singly or screwed together to a length of as much as 200 feet, these become the

"LANDSCAPING" by German military engineers removes natural features that would shield attackers. Upper picture shows how a field gun could be sheltered from direct fire by a small hill. Below, how the same terrain would look after landscapers did their work, with all approaches fully covered by the fort's guns





All around Hitler's Europe, frowning guns face seaward in readiness for Allied landings. These Italian defenses, built into the face of a cliff, guard a section of the Mediterranean front. Beyond the coastal area, invaders will encounter deep belts of fortifications such as the famous West Wall of Germany

famous bangalore torpedoes, so devastating to wire entanglements. A few men carry grappling hooks to explode booby traps and antipersonnel mines by the simple expedient of tossing them ahead and pulling them back to catch trip wires. Of utmost importance are the soldiers with charges of TNT slung around their necks in satchels, carried in steel containers, or on long poles for shoving into bunker portholes. Most of the men lug hand grenades and one or two have smoke grenades. Only a handful carry rifles, but close by, protecting the advance, assault infantry bangs away with Garands.

In the vanguard at the outset are soldiers with grappling hooks. They clear the way for safe passage across the fields. When the crew reaches the inevitable ring of wire entanglements, the bangalore boys take over and make short work of that obstacle with a deafening blast. The explosion also destroys antitank mines within three feet of either side.

Thus the first real break-through occurs, and now the attackers are covered even more closely by high-velocity guns, including those mounted on tanks, that roll up to within 1,000 yards of the target. At this juncture, the heavy artillery to the rear raises its lobbing fire to enemy emplacements beyond those under attack.

Direct fire screams over the heads of the advancing fort busters, who now are approaching their objective. The men with the 70-pound flame-thrower tanks on their backs, copper nozzles in hands, edge into the lead. Their movements are agile, despite their load. They know the tricks of their trade. When they run and fall, they land in a rolling movement that eases the tanks to the ground. Otherwise they might break their backs. They roll over to a crouch before rising.

In the home stretch, all the men crawl forward till the target looms only a stone's throw ahead. Here the leader (a corporal commands each detachment) lets fly with a signal rocket. There's a final burst of direct fire, in the last salvo of which is a smoke shell, indicating the shift of the bombardment to adjoining bunkers. Now is the time for demolition. Into action go the bazookas, those weird tossers of ultrahigh explosives. Their projectiles smash at the embrasures in ear-rending blasts. At 20 yards, the flame throwers begin spouting long, roaring jets of burning oil and gas that blanket the bunker in a mass of fire.

The instant the flame throwers zip off, in rush the blasters with TNT. They explode charges at the bunker doors with a delayed-action fuse that barely gives them time to run back a few paces and throw themselves to the ground. Timing is geared to a split second. No sooner does one charge go off than another *(Continued on page 202)*

When the signal is given, the enslaved peoples of Europe will spring to action everywhere. The compact, fast-firing, easy-to-operate Sten gun will kill many Nazis behind the lines while the Allied armies fight on the newly opened fronts

Sten Gun To Be Forerunner

THOUSANDS WILL BE PARACHUTED TO GUERRILLAS

"A HUNK of pipe—with a door spring in it," is the apt description given the new British Sten submachine gun, which soon may be plummeting from the skies over Europe into the eager arms of Frenchmen, Poles, Czechs, and others who want to fight their way out of slavery.

Faced with the problem of producing in quantities a gun simple enough to be operated by the untrained peasants who will become Europe's new guerrilla fighters, British ordnance experts threw out all previous notions of armament making and came up with this gun (P.S.M., Sept. '42, p. 65; Jan. '43, p. 131) that made orthodox military thinkers gasp. But even the skeptics gave in when they saw the ugly duckling in action. Capable of firing 500 to 550 rounds a minute, this sturdy, six-pound package of dynamite can be operated by a child. It doesn't even require oiling. It has

Sighted from the shoulder or shot freehand from the hip, the gun has a 32-round magazine and fires 500-550 rounds a minute. It is easily dismantled for convenient carrying

Parachutes will drop the cheaply built Stens to the peoples' armies, along with the bullets to fire in them. But enemy munition dumps will also be a handy source of supply as the gun shoots many Axis types of ammunition

British paratroopers also tote the Sten gun. When dropped behind enemy lines, they need a light weapon they can bring into operation fast

Drawings by B. G. SEIELSTAD

# of Invasion

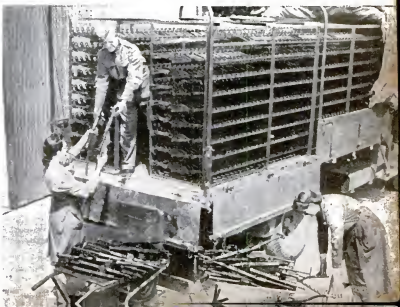
BEHIND AXIS LINES

"Invasion guns" are turned out fast on assembly line of this Canadian factory. Some are already waiting for action in secret underground arsenals in Europe

only two machined parts, the bolt and the barrel; every other part is the cheapest kind of stamping. Firing is accurate up to 100 yards.

What's more, engineers thoughtfully designed the Sten to fire all types of 9-mm. Parabellum ammunition and most other shells of the same caliber. Guerrilla fighters will be thankful for this foresight when the "big push" comes and they begin to take over enemy ammunition caches, for they will be able to load Sten magazines with cartridges made for German Schmeisser and Bergmann submachine guns, the Italian Beretta machine carbine, and a wide range of Axis service rifles and carbines.

Because the total cost of the carbinelike weapon is under fifteen dollars, they can be made in huge quantities for generous distribution where they will do the most good



A collapsible stock and detachable barrel make it possible for the gun to be broken down into three parts, none more than a foot long

SUBMACHINE GUN. Known as the M-3, this handy 45-caliber weapon, designed by the Army for parachute troops, spits out 450 rounds per minute with good accuracy at short range. Almost toy-like in appearance, the gun weighs nine pounds, and when collapsed will fit into a brief case. It is made mostly of stamped parts, and can be mass-produced for only $20. Amazingly rugged, the gun is said to be comparatively unaffected even by immersion in salt water.

CLEARING A PATH through mine fields is a ticklish job for the combat engineers, even with this hypersensitive mine detector. Powered by batteries, the instrument is an adaptation of the metal finder used by prospectors. As it senses buried metal, a buzz is transmitted to the operator's earphones. The louder the buzz, the closer the mine, and the engineer marks the spot with pegs as a guide to sappers who will be sent to remove the mine from the path of advance.

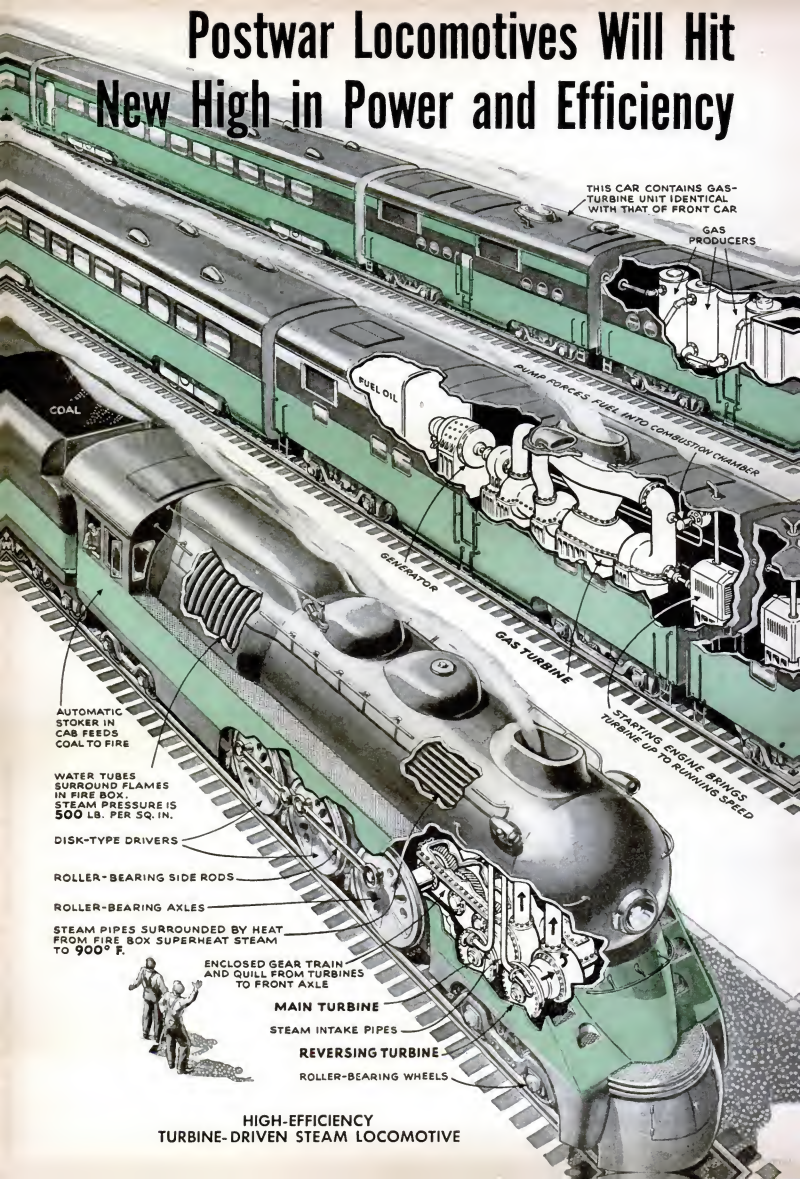
THIS PORTABLE PRESSURE CHAMBER shows which of our airmen can fly high. It is used by a U. S. Air Provisional Medical School in England to test flyers' physical condition and their reaction to high altitudes. The flyer enters the chamber, an airtight door is closed, and the air is slowly pumped out to simulate high-altitude conditions. The men are tested with and without oxygen masks, to ascertain their reactions at various degrees of pressure.

Above, an operator controls the amount of air that is pumped from the chamber to reduce the pressure. Right, a supervising officer peers through a window to observe 'flyers' reactions

TORPEDOED. Seamen disembarking in a Canadian seaport on the Atlantic coast enjoy having themselves ferried to shore through the gaping hole left in the bow of a freighter by an enemy torpedo. The hardy seamen have a grim name for the trip. They call it the "Scenic Route." Water taxis shuttling back and forth across the harbor find that the novel passageway, which is large enough to accommodate a fair-sized dingy, provides them with a convenient short cut. Attacked by a submarine in the Atlantic, the vessel, as can be seen from the photograph, was solidly hit. Instead of sinking, however, the stout vessel righted itself and the crew brought it to port without aid.

SHIP FENDERS, designed to protect vessels from damage when they refuel or take on cargoes at sea, are now being made of fir from the Pacific Northwest, instead of oriental wicker, which is no longer available. The fir poles are first cut to length, then driven into place in a wooden frame. A woven network of rope holds them fast. Fenders are hung over a ship's side when it goes alongside another vessel to transfer fuel or cargo, to prevent their scraping.

Postwar Locomotives Will Hit New High in Power and Efficiency



HIGH-EFFICIENCY
TURBINE-DRIVEN STEAM LOCOMOTIVE

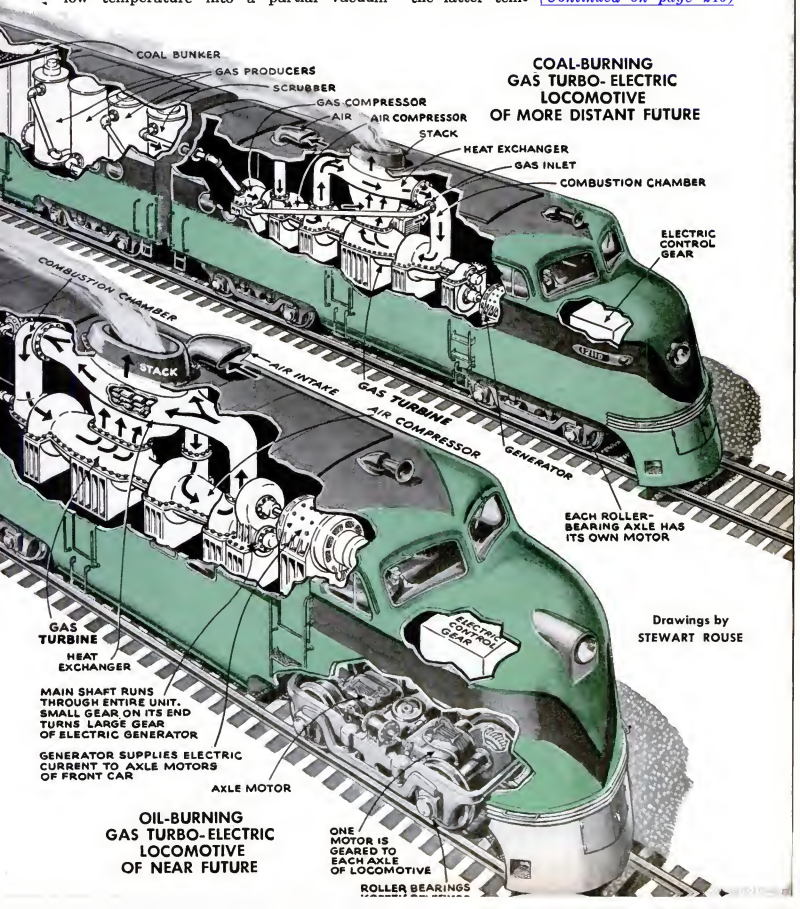
By CAPT. W. MACK ANGAS

Civil Engineer Corps, U.S.N.

The opinions expressed in the following article are the author's, and should not be interpreted as those of any department of the Government.

WHEN the new techniques and materials developed by the war are finally directed toward industrial problems of peacetime, one of the machines most likely to experience radical departures in design and construction is the railroad locomotive.

The familiar steam locomotive will still be with us for a while—but it, too, will undergo revolutionary changes. Air and water-cooled condensers that increase the efficiency of stationary and marine steam engines by permitting them to exhaust at low temperature into a partial vacuum have, as yet, proved impractical for use on a locomotive. But there is no reason why the engine's efficiency cannot be increased by stepping up the pressure and temperature of the steam that drives it. A fire-tube boiler used in conjunction with a water-tube fire box, such as has already been developed, may readily raise current pressures of about 250 pounds per square inch to 400 or even 500 pounds—with a superheater to raise the steam's temperature from 600 to over 750 degrees F. Since steam much over the latter tem- (Continued on page 210)



At right are shown three metal airplane parts, with the new plastic dies which have been used to form them. In addition to speeding up production, the dies also save critical metal

THERMO-CAST, a new plastic developed by Prof. James M. Church, of Columbia University, New York City, is expected to speed up production of thin structural airplane parts by 50 percent by replacing the metal tools ordinarily used to form them. Extremely hard, with a high impact strength, the new plastic melts at a much lower temperature than metal and can be cast with considerably greater exactness.

"DUCKS," the Army's new 2½-ton amphibian trucks, are playing an important rôle in landing military supplies on the beachheads of the Pacific. Maneuvering alongside a freighter (left), the big duck takes aboard its load, cargo net and all, and "swims" back to the crane (below). The vehicle can also be used to ferry troops and equipment ashore from transports during the early stages of landing operations.

Hexamethylenetetramine, an important ingredient in the high explosive with which American flyers are smashing German military and industrial targets, can be traced back to plain coal, air, and water

Secret Chemical Puts More "Bust" in Block Busters

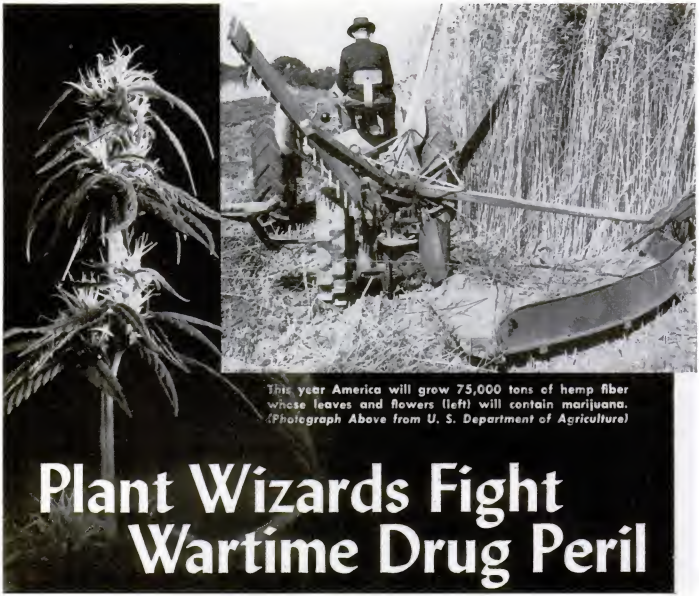
Hexamine crystals being shoveled from an evaporator at a Du Pont electrochemical plant. They will be granulated for use in preparing the explosive

AIR, coal, and water, broken down and recombined by chemists, form the basic ingredient of a new secret explosive that daily blasts Axis war plants, naval bases, and air fields. Known technically as hexamethylenetetramine—or hexamine, for short—this complex organic chemical has long been used as an "accelerator" in the vulcanizing of rubber and the making of phenol-formaldehyde plastics. Under the name of urotropine, it also serves as a vital medicament in the treatment of diseases of the urinary tract. Since Pearl Harbor, however, the Du Pont electrochemical plant, at Perth Amboy, N. J., has been producing, for use in the new explosive, vast quantities of specially treated hexamine whose grain size, moisture content, and other properties are carefully controlled. Resembling sugar in appearance, hexamine is produced by a secret method of combining liquid formaldehyde and liquid ammonia. The resulting solution is passed into an evaporator where it is boiled down into a crystalline state. This substance is then dried and ground into granulated form.

One of the virtues of hexamine is that, unlike TNT, it requires no critical materials. Formaldehyde is made from air and synthetic wood alcohol, the latter being made from coal and water. Synthetic ammonia is produced from nitrogen from the air and hydrogen from water, water gas, or coal gas.

Total production of hexamine in the U. S. during 1941 amounted to 4,000,000 pounds. Since then many new plants have sprung up to increase that amount many times over, and to insure an ample supply of the once harmless chemical which now combines with others to produce shattering destruction. Just how this combining is done, of course, must for the present be left for the chemical wizards of the "master race" to figure out.

Can we have rope without dope?



This year America will grow 75,000 tons of hemp fiber whose leaves and flowers (left) will contain marijuana. (Photograph Above from U. S. Department of Agriculture)

Plant Wizards Fight Wartime Drug Peril

We need hemp—lots of it—for cordage, but hemp means marijuana, too. Can scientists take the drug menace out of this useful plant?

By ALDEN P. ARMAGNAC

CO-OPERATING with the U. S. Department of Agriculture, American farmers will produce 75,000 tons of hemp fiber this year, and probably more than twice as much in 1944. The record-shattering crops will replace Manila fiber from the Philippines and sisal from the Dutch East Indies, which are now cut off by the war.

The result will be a boon to users of cordage—and a headache for law-enforcement officers. A Jekyll-and-Hyde plant, hemp provides twine and rope urgently needed for military purposes. But it also yields marijuana, a drug that makes depraved creatures of its addicts. What can be done to keep these enormous new supplies, from which there almost inevitably will be "leaks," out of their twitching hands?

"Drugless hemp" is the bold proposal of the Department of Agriculture for solving the problem. In short, it is attempting to breed a strain of hemp of good fiber quality, but containing a negligible amount of the baneful marijuana drug. For aid, it has enlisted the expert services of Dr. H. E. Warmke, at the Cold Springs Harbor, N. Y., experimental station of the Carnegie Institution.

First of Dr. Warmke's problems has been to develop a method of determining reliably the amount of marijuana in individual hemp plants. With undesirables weeded out, he then cross-pollinates and breeds the desirable, or relatively drug-free, plants. Only a little more time will be needed to learn whether he can establish a pure, self-perpetuating race of them.

Fish serve as test animals for determining the potency of marijuana extracts. Previous

This little fish, shown actual size, plays an important role in the fight to breed a drugless hemp.

1 The seedling of one of many plants being bred to reduce the marijuana content of hemp

2 Dried center leaflets from each leaf of mature plant are ground to powder in mortar

3 Measured amount of powder is put in vial, and a chemical is added to extract marijuana

4 To determine the potency of the extract, a pair of killifish are placed in each of four beakers containing solutions of the drug ranging from very strong (left) to weak (right). In this way, the number of fish that are killed gives a graduated measure of the amount of marijuana in the plant tested

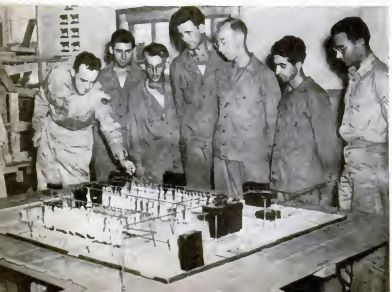
experimenters have used dogs, and tried to estimate the extent of their marijuana "jag"—something hard to reduce to cold figures. But when a fish is placed in a strong solution of marijuana extract, it soon is most thoroughly dead, and such an observation cannot be disputed. Therefore, Dr. Warmke puts two killifish, or "Atlantic minnows," into each of four beakers containing precisely measured dilutions of the drug—very strong, strong, medium, and weak. Then he can record the number of fish killed and get a definite measure of the poison in the plant.

First encouraging results show a great range in the amount of marijuana in different hemp plants. Some prove to be one eighth as poisonous as others, an excellent starting point for a plant breeder. And actual breeding has definitely resulted in improvement. With true scientific caution, Dr. Warmke refuses to admit having "Burbanked" a drugless hemp until a few more plant generations have been tested, but to a layman's eyes he seems close to his goal.

5 In effort to breed a "pure" hemp, plants with low toxicity are cross-pollinated by shaking pollen from male plant (right) on stigmas of female

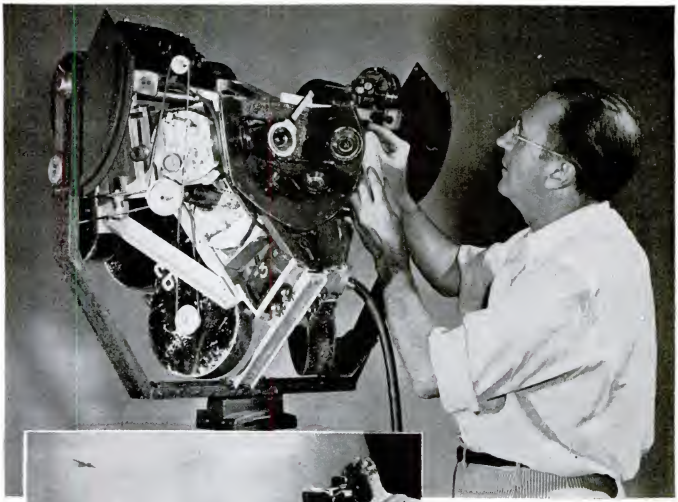
THREE-IN-ONE COMBAT GLOVES mean the difference between frozen fingers and victory in high-altitude dog fights for flyers of the Royal Canadian Air Force. Successive layers are shown from left to right above. The innermost, made of rayon, has thumbs and forefingers latex-treated to make paper handling easy. The second pair, worn over the first, is of wool, with easy-grip thumb pads of leather. The outermost gloves, of horsehide, have fingers curved like those of worn gloves.

SCALE MODELS teach Quartermaster personnel their jobs in the Corps school at Camp Lee, Va. Above, future Army cooks and mess sergeants learn how to set up a standard field kitchen. Below, a model of a refrigeration plant uses toy-size models of meat carcasses.



AN AIR-AGE GLOBE manufactured by Rand McNally demonstrates the new routes and distances in an air-minded world. The 12-inch globe can be lifted from its attractive glass base, held in the lap, or passed around like a ball. Free of the old axis rod, meridian, and horizon ring, it gives a true conception of our earth as a free-floating sphere. This globe is an aid in keeping abreast of the war news.

Supplied with this free-moving globe is a plastic tape scaled in nautical and statute miles for measuring both air-line routes and surface distances



FIVE-LENS CAMERA for filming attacking planes is set in same position in bomber as gunner later will occupy. Fred Waller, Trainer's inventor, is shown loading film in camera

TARGET PLANE'S image travels across screen while gunners try to hit it with imaginary bullets. Button on control panel permits instructor to throw light on screen that shows where student is aiming, so he can advise corrections through earphones

Movies Train Air Gunners

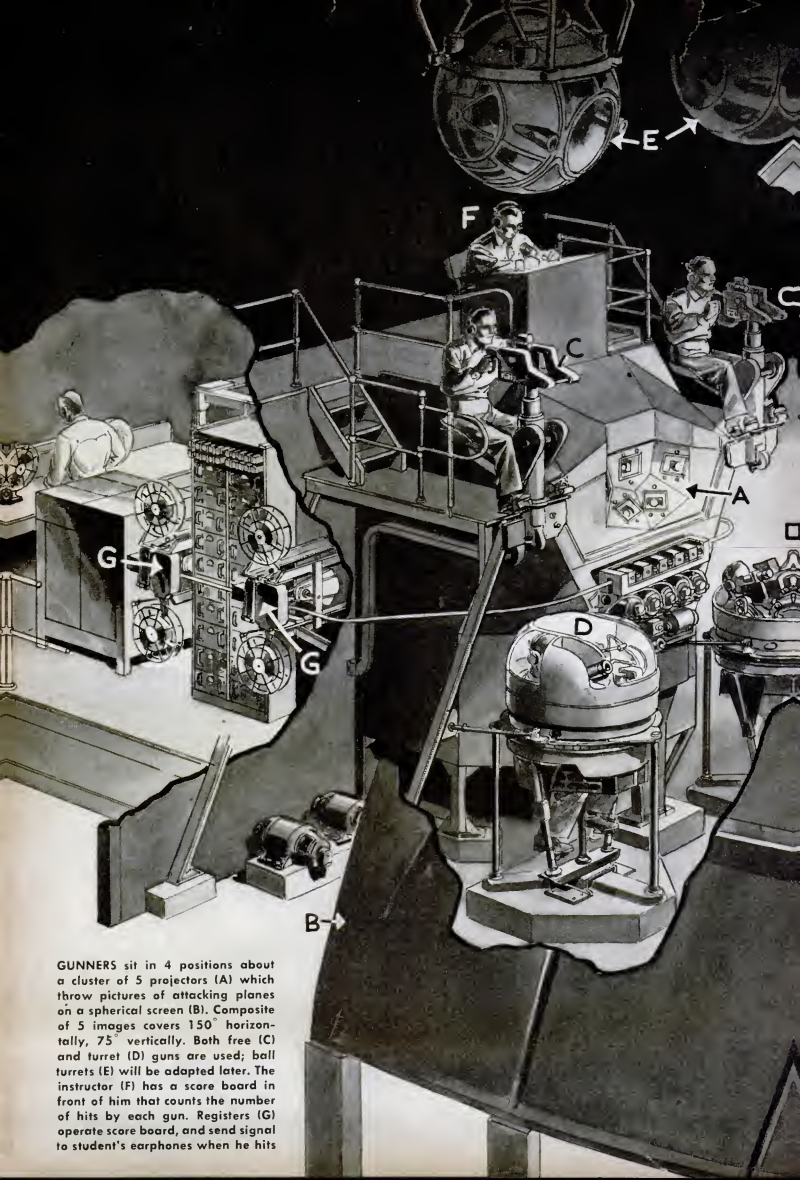
FLYERS BLAST PHANTOM PLANES IN BATTLE PRACTICE

By WILLIAM CRIST

Drawings by B. G. SEIELSTAD

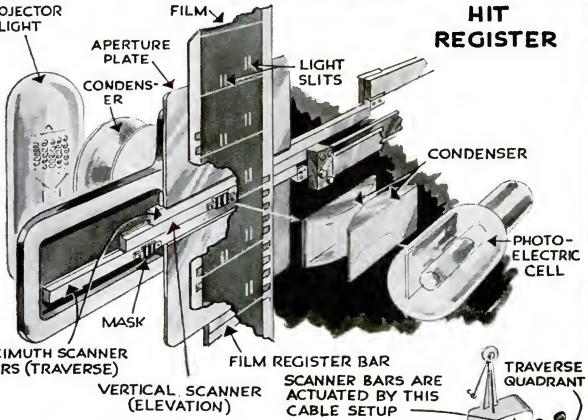
TO BRIDGE the jump between shooting at slow-moving sleeve targets towed in a straight line and shooting "live ducks," aerial gunners now are getting their final licks on the Waller Gunnery Trainer. Developed by Fred Waller, who formerly was in charge of special effects for Paramount Pictures and more recently head of their short-subjects division, the Trainer reproduces, on a mammoth concave movie screen, attacks by dodging, twisting fighter planes, and shows the gunners how to hit them.

The screen is a segment of a sphere, measuring 40 feet from end to end. On this is thrown a picture by five projectors, each covering a separate portion of it. Twenty feet in front of the screen sit the trainees, each in one of four gun positions. They have two gun handles in front of them, just like

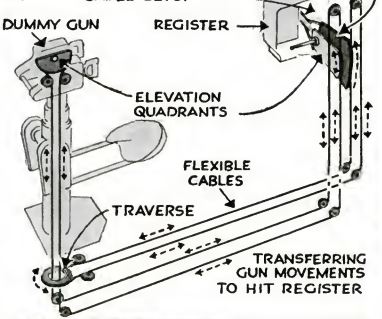


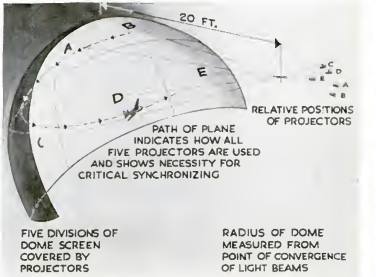
GUNNERS sit in 4 positions about a cluster of 5 projectors (A) which throw pictures of attacking planes on a spherical screen (B). Composite of 5 images covers 150° horizontally, 75° vertically. Both free (C) and turret (D) guns are used; ball turrets (E) will be adapted later. The instructor (F) has a score board in front of him that counts the number of hits by each gun. Registers (G) operate score board, and send signal to student's earphones when he hits

HIT REGISTER



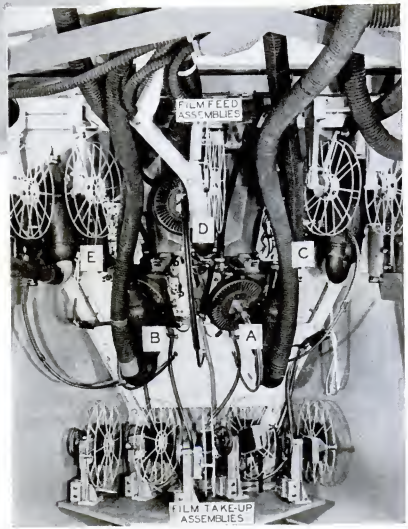
HEART OF WALLER TRAINER is hit-recording mechanism. As gun swings in ozimuth ond zenith, cables mave quadrants (right) which mave 3 scanner bars (abave) across register film. Film hos set af light slits for 75° vertical angle, ane far each half of harizantal thraw. Their lacatian is set by plotting distance to attacking plane against time it takes bullet to reach it. Film is thrown on o screen, a frame at a time, and position of the plane nated. It then is advanced ta shaw pasition at end of time lapse. (Mavie film gaes through a projector at 24 frames per secand.) This new spot is where gun should be aimed sa bullet gets ta the secand pasition at same instant plane daes. It is marked by a light beam whase location on the screen is tronsmitted to the 3 masks in o projectar laaded with register film, which ore moved in the same manner as the scanner bars. These masks pass slits of light to the film in order to expose an it positian of the light beam an screen. When gun in Trainer is an carrect "paint of aim," the scanner bars are maved by the gun's cables inta o scoring position, permitting light to pass through slits in them and through the transparent marks in the film. The light strikes a phatoelectric cell, which clases a relay, sending signals ta both gunner ond hit indicatar on the cantral baard



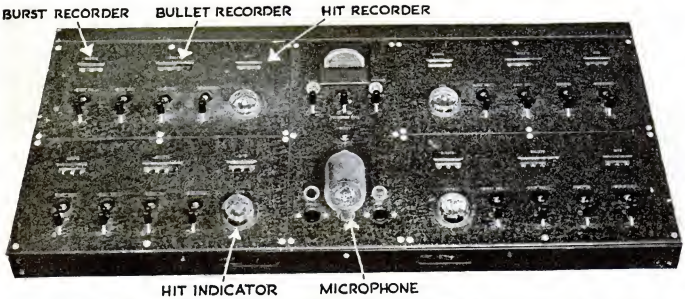


DIVIDERS are used to measure wing span of plane so its distance can be calculated. In recording hits, allowance is made for scatter of bullets after firing

PROJECTION EQUIPMENT handles 9 rolls of film at a time; 5 of these are picture film, 4 are the register bands. Synchronous motors run all at same speed



those on a real .50 caliber machine gun. When the image is thrown on the screen, they can see the wing tips of their own bomber, as well as the approaching fighter. They lead it in their standard Mark 9 reflector sights, pulling the trigger when they think they are on the correct "point of aim." If they are in a free-gun position, instead of a turret position, the gun handles start jumping, the vibrations carefully reproduced to simulate those of a real gun. Through earphones they can hear the authentic sound of their own guns. When a hit is scored, it sounds a 1,000-cycle "beep" in their ears and moves a register on the instructor's control panel. The Army Air Forces also use the Waller Trainer.



CONTROL PANEL shows number of bursts and bullets fired and keeps record of hits. The hit indicator also flashes on when a student scores a hit. If light stays out too long, instructor checks student's aim

A 16-WHEEL TRAILER is being used at a large shipyard, engaged in the mass production of Liberty ships, to haul giant prefabricated sections from the assembly shop to the ways. Rolling on rubber-tired wheels and capable of handling loads weighing as much as 80 tons, the trailer is drawn by a Diesel tractor. Both the trailer and tractor are products of the Caterpillar Tractor Company, of Peoria, Ill.

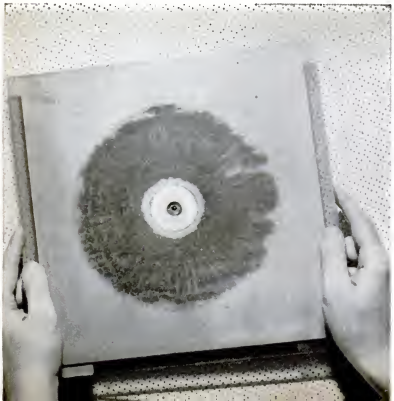
INNER SOLES made of a new "ventile" wool and designed by the American Felt Co., Glenville, Conn., "exhale" the moisture from perspiration and thus protect troops stationed in Arctic regions from the danger of having ice form in their shoes. Each sole consists of two hinged pieces which "work" under pressure.

THE RUBBER LUNG, a device for administering artificial respiration, has been introduced by the E. D. Bullard Company, of San Francisco. Strapped to the patient's body, the resuscitator is operated by rhythmically depressing and raising the handle. This activates the abdominal muscles and diaphragm, causing the patient to inhale and exhale until his normal breathing has been restored.

ONE-MAN FORTRESSES now command the centers of many of the French and Scandinavian towns occupied by the Nazis. The tiny fort at the left, the size of which can be judged by comparison with the soldier standing beside it, consists of an armored revolving dome set on a heavily armored base. The recent increase in the number of these miniature pillboxes, which are to be found for the most part in coastal villages and towns, gives strong indication that the Germans are now on the receiving end in the war of nerves, and are frantically fortifying themselves against attack by Allied invaders and by enraged natives of the occupied countries.

PORTABLE ELECTRIC MEGAPHONES are now carried by merchant ships for use when bombs or torpedoes knock out the regular communication systems. Powered by a battery carried in a case slung over the shoulder, the instrument amplifies the human voice to permit the giving of commands to gun platforms, engine room, and lifeboats.

BULLET "FOOTPRINTS," left on lacquer-coated targets by the impact of speeding projectiles, are giving Westinghouse scientists new information that may help them to develop tougher armor plate and better armor-piercing shells. When a rifle is fired at a target, as at lower right, stresses set up in the target material are permanently recorded as cracks in the sprayed-on, brittle lacquer coating. On the target below, dye has been added to bring out the circular pattern of lines around the point of impact.



Robot Brain Aims Turret Guns

COMPUTING SIGHT GIVES BOMBERS DEADLY FIRE POWER

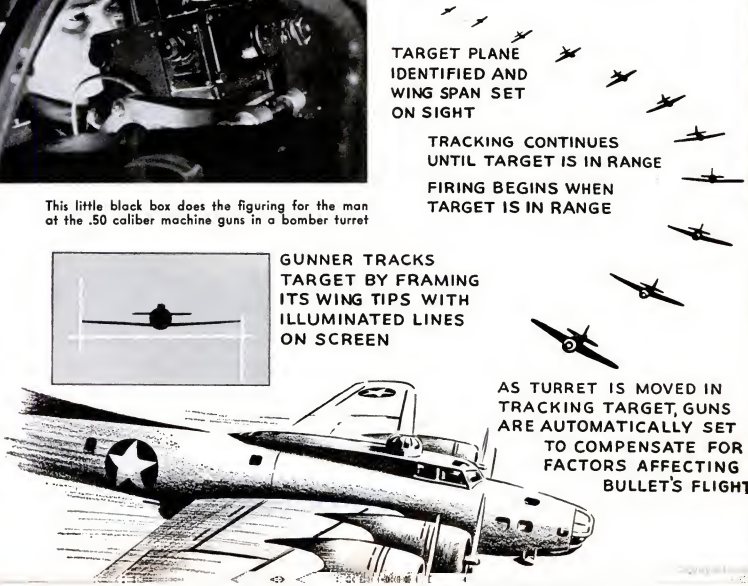
AMERICA'S Flying Fortresses and Liberators have enjoyed their signal success at daylight bombing over Europe and in the Pacific because of their terrific fire power, which enables them to fight their way in and out against the best Axis fighter opposition. Behind this deadly bomber defense is a little black box which has, heretofore, been kept on the "secret" list. This is the new Sperry Automatic Computing Sight, a compact and simply operated mechanical brain that does most of the gunner's thinking for him.

Its use has resulted not only in greater accuracy but in increased range. Twin .50 caliber guns fitted with the automatic sight now have an effective range of more than 1,000 yards. Mounted centrally between the guns, the sight swings or raises or lowers as the guns are tracked. The gunner peers into an optical sight, keeping the enemy plane "framed" between two vertical lines. He may alter the distance between these lines by moving a pedal with his left foot, and as long as these lines frame the hostile ship, the guns are "on target."

Upon attack, the gunner moves a small knob on the right side of the little black box to correspond with the known wing span of the enemy plane. Recognizing the attacker as a Messerschmitt 109G-2, for example, the gunner sets the knob so that the scale reads 33, the plane's approximate wing span. As the plane approaches, the gunner keeps it framed by moving the vertical lines in his sight with the foot pedal.

Although he seems to be aiming directly at the enemy ship, the guns are actually pointed ahead of the plane, "leading" it as in skeet or duck shooting. Allowance is also made automatically for vertical ascent or descent and the effect of the wind. Since deflection and windage have been two of the gunner's biggest problems, the new sight will speed training of new gunners.

This little black box does the figuring for the man at the .50 caliber machine guns in a bomber turret



SWIMMING WITH A PACK is not as difficult as it sounds. Far from weighing him down, a soldier's regulation 60-pound load will actually provide enough buoyancy to keep him afloat for a time. When the equipment is properly arranged, air is trapped inside the bag and remains until the fabric is thoroughly soaked. The swimmer is so well supported that he can even aim and fire his rifle while floating in midstream. If he has no pack, a fighting man can apply the same principle by knotting a pillow slip or even a pair of pants so that it will hold enough air to take the place of water wings or a flotation bladder. Such tactics will be handy in landings and other amphibious operations.

Pvt. H. T. Christoffersen demonstrates the knack of floating with a full regulation pack and aiming his rifle at the same time

HOME, SWEET HOME for glider mechanics at advanced invasion bases will be the seven by 24-foot weatherproofed crates in which their gliders reach them. Student mechanics in training at Sheppard Field, Tex., are taught how to make themselves at home in the boxcarlike crates in preparation for the day when they will use them as huts. At the left, trainees are seen moving cots and bedding into one of the crates, which they christened "Glider Inn."

Looking Ahead

LIFEBOAT REFRIGERATOR. A Toronto manufacturer, working with medical researchers, has perfected a lifeboat refrigerator which makes fresh-water ice out of sea water, then obligingly melts it again for drinking if the temperature is below freezing point.

WOBBIE. A Netherlands Luther Burbank has crossed a carrot with a beet and come up with the hybrid "wobbie," guaranteed to taste better than it sounds. This plant—said to be the first new root vegetable introduced into agriculture in a generation—contains almost four times as much vitamin C as either of its progenitors.

NEWEST TRICK in camouflage is the dark-green paint concocted by Du Pont scientists to make Axis aerial photographers look foolish. The new paint reflects infrared rays and, when photographed, shows up just as light as real vegetation, effectively hiding vital buildings from a prying infrared camera eye.

PLANES OF THE FUTURE may be stuck together, not with rivets and weld spots, but with an adhesive tape said to be stronger than both. Cycleweld, a new plastic cement tape developed by Goodrich, is sandwiched between two sheets of metal with heat and pressure to form a liquidtight and airtight seam.

Strip Germany of Machine Tools!

POPULAR SCIENCE MONTHLY offers a plan for disarmament that would reach down to the roots of the Nazi war menace.

THESE ARE BASIC PROCESSES OF ARMS PRODUCTION

CASTING

Foundries provide heavy parts for war machines.

FORGING

Heated metal is hammered into shape and toughened.

MACHINING

Lathes, shapers, and other machine tools work metal.

GRINDING

Abrasive wheels give precision finish to all work.

WELDING

Arc or flame joins parts in fabrication of weapons.

DE-INDUSTRIALIZE Germany. Strip her of the tools and machines that are the basis of all war production. That is the proposal offered by POPULAR SCIENCE MONTHLY as the only way to make sure that 80,000,000 Germans will never again spread the disease of war throughout the world.

Disarmament of Germany is a fundamental of any plan for securing the peace of Europe. But this time we must do the job right. We must not repeat the almost fatal mistake that gave the Nazis their head start on the road to world conquest in 1939.

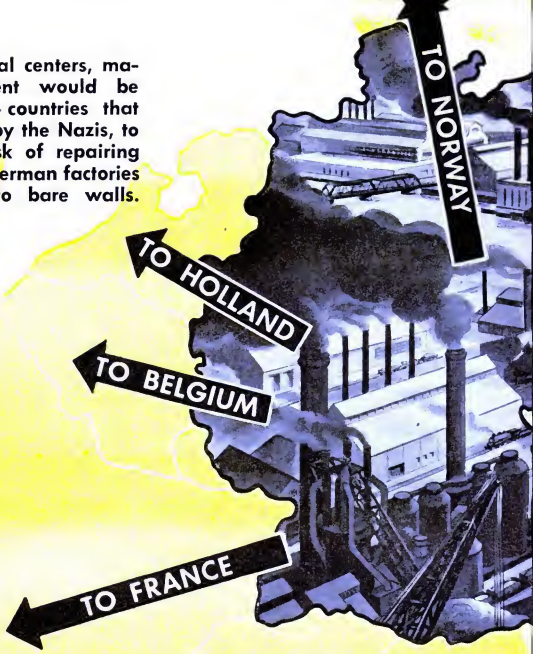
That mistake was the assumption that rearmament begins with the actual production of guns, tanks, and planes. In modern, mechanized warfare, that is only the final step of a long and complicated process. The groundwork is the building up of a vast supply of machine tools and of the skilled labor to operate them, with the foundries, blast furnaces, mines, and other installations needed to feed them with materials.

To manufacture a 25-pounder field gun requires about 7,000 tools, ranging from a 2,000-ton press to 1½-foot grinders. It calls for thousands of jigs, tools, and gauges, with some 40 traveling cranes and equipment for tempering. Making the 45,000-odd parts of a bomber, or the 40,000 parts of a tank, is likewise a job only for organized industry.

The insidious thing about machine tools is that they can serve as well to make the implements of peace as to forge the weapons of war. Lathes, presses, and milling machines can be turned in a moment from manufacturing vacuum cleaners and washing machines to producing bombers and cannon. Furthermore, they are the only creations of man that are self-regenerative. Machine tools can breed more machine tools, pyramiding productive capacity at an almost unbelievable rate.

These facts served the Nazis well in their carefully planned preparations for the present war. Long before they made the first move in defiance of the Versailles Treaty, they had multiplied their machine-tool production enormously. When M-day came, it was necessary only to switch over these machines to war production with the aid of secretly prepared gauges, jigs, fixtures, and tools. While the British and French were

From German industrial centers, machines and equipment would be moved away to the countries that have been despoiled by the Nazis, to help in the giant task of repairing the ravages of war. German factories would be stripped to bare walls.



THESE FACTORIES MADE THE WAR

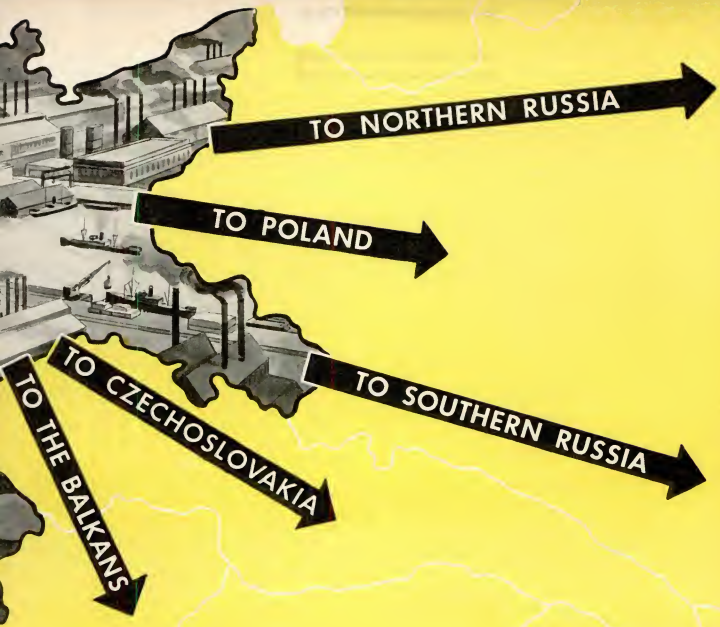
trying frantically to create a large-scale armament industry overnight, the Germans poured forth a flood of war materials that nearly gave them world domination.

The same thing will happen again if Germany is allowed to retain her heavy industry and her machine tools. It is too easy to change over from peacetime manufacture to war production. Disarmament must go down to the roots.

How would this be done? To get the answer, POPULAR SCIENCE MONTHLY canvassed engineers and manufacturers of machine tools and heavy machinery—men who know how to forge the weapons of war and how to convert plants from peacetime production to the building of guns, tanks, and planes. Many of them had dealings with German industrialists during the period when Hitler was rearming the Reich. One is a former German engineer who witnessed the mockery of the "disarmament" that followed the last war. All know how futile it is to try to win a modern war without complete leadership in industrial production.

These men say that the only way to disarm Germany effectively is to strip her factories of everything they contain, even to the steel girders. Much of the machinery will be worn out after years of forced wartime use without proper replacements. What is still usable would be divided among the countries the Nazis have despoiled, to help them in the big job of reconstruction. Foundries, blast furnaces, and mines would be dismantled.

The plan would have to be carried out by men who know machines and what they can do for peace and war. An inter-Allied commission of engineers and industrialists would go through Germany's factories and mills, checking all equipment that was fit for salvage. Distribution would be governed by the needs of the various countries to be reconstructed and the amount they have suffered. Equipment for mines and blast furnaces would be shipped to cities like Lille and Kharkov, where they could be used.



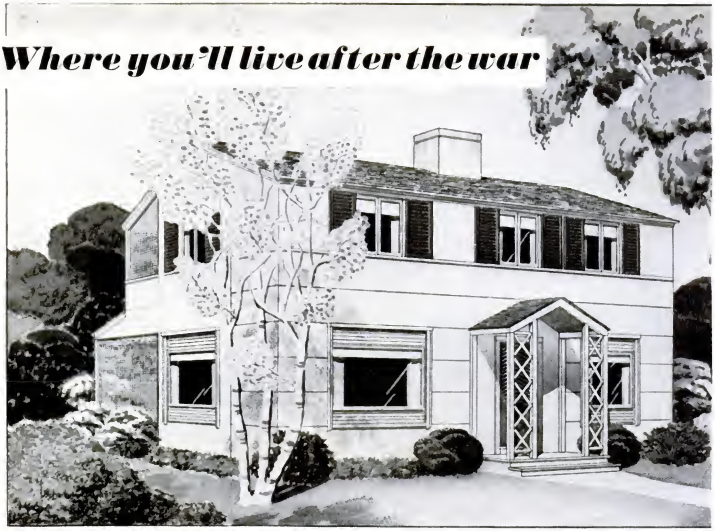
...LET THEM REBUILD FOR PEACE

As for the future, strict supervision of German industrial life would make certain that no new start was made toward building up a potential war production. Machine tools and heavy industry would be taboo, until the German people have given proof that they have lost their inveterate urge for conquest.

Is the plan feasible? Yes—if it is administered conscientiously by statesmen and technicians, with full co-operation and support by all the United Nations. It isn't easy to hide the growth of a war machine. Before the present war, it was no secret that Germany was rearming. Even after the preliminary period of planning and experimentation, it took the Nazis six years of intensive work to get ready for the test of battle. It needn't have happened—and it must not happen again!

If this proposal sounds ruthless, it has ample precedent from the Germans themselves. Almost their first act of aggression was aimed at Czechoslovakia, with the primary object of grabbing her highly developed industries. As the Luftwaffe and the armored divisions swept over Europe, their engineers went through the factories and carted off anything they wanted. When it was not expedient to carry away the equipment, they moved in and exercised control for their own purposes.

What would become of German economy if this plan were put into effect? It is no light matter to turn back the clock 50 years in a highly industrialized country. Germans would have to learn to live under an agrarian and handicraft economy, at least until the virus of war was definitely eliminated from the national mind. Their industrial genius might be employed, under strict control, in the rebuilding of the countries they have ruined. But, at worst, their condition would be no harder than it was during the years of "guns or butter," and civilization would be saved from the catastrophe of another world war. If this is the price of permanent peace, it is a bargain.



Your Home...*Tomorrow*

Here's a preview of the house you'll get when peace comes . . . a prefabricated home with built-in conveniences and comforts for modern living.

By CARL T. SIGMAN
and WILLIAM J. WARD, JR.

IN YOUR postwar home you will find a fifth freedom—freedom from most of the traditional inconveniences, inadequacies, and high costs of the house of the past. In short, freedom to live in that same postwar future.

Everyone knows that the automobile of tomorrow will be very different from the last prewar models. The same will be true of radios and refrigerators, ranges and furnaces, sanitary and electrical equipment, and even of the roofs, floors, walls, and windows of our new houses. In some of these, improvements have come in the past at widely spaced intervals; others have seen minor annual changes. But it never seemed to the manufacturer that he could afford to scrap all his dies, tools, and machinery to make a revolutionary change in his product, however far ahead of him his engineers and architects might be. Now, however, all his equipment has been scrapped to meet war demands, and with peacetime conversion he will be free to build the best refrigerator, range, bathroom—or the best house—that his engineers, designers, and architects can conceive, however revolutionary it may be in material, structure, or equipment. Besides being freed from the restriction of existing equipment, these building industries will find themselves aided by recently developed new materials and by astonishing new uses for old ones. The result is bound to be something very like a revolution in house building and equipment.

Your home of tomorrow will be a better and a cheaper house—one designed of modern materials, by the best modern engineering thought and facilities, and geared to modern living. It will be cheaper because it

will be largely or wholly prefabricated. But it will be a far cry from the boxlike "modern" houses that we have known. Prefabrication will at first accommodate styles of design familiar to us, but it will gradually adapt itself more, functionally, to modern living.

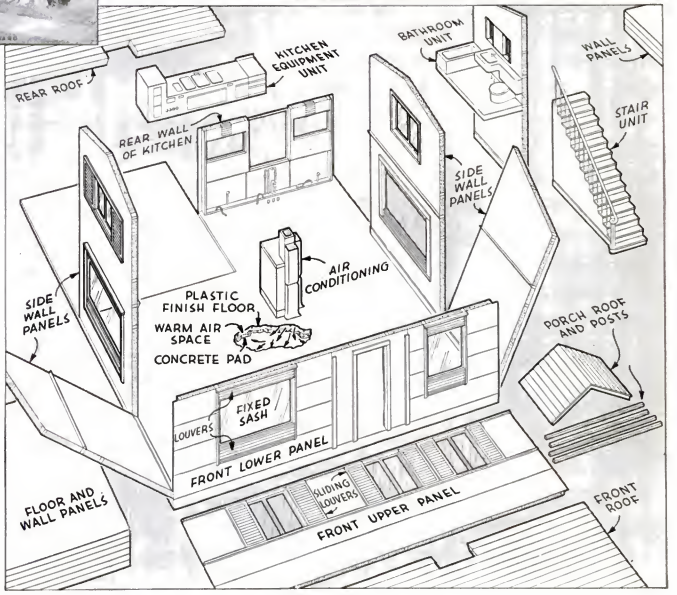
The manufacturer will make your house of tomorrow in wall slabs, roof, and floor sections that can be shipped to you in a flatcar. Into the lighter and thinner walls will be built insulation, hot and cold-water pipes, and, in some instances, soil pipes. They will be completely wired with continuous base outlets. The ceilings may come with concealed cove lighting.

Plywood glued in place will make outside and inside walls tighter and stronger than our present ones. Or the interior ones may be made of new plastic materials that can be wiped off clean, will never develop unsightly cracks, need never be papered or painted, but can be, if you wish. Or they may have semi-porous surfaces that absorb sound, and into which nails can be driven and withdrawn without leaving holes.

Windows and doors will come in certain of the sections, but, far from determining a standardized design, these sections will fit into houses of innumerable architectural types. Your architect has only to choose the particular section that his design

The walls, partitions, roof, and floors of the house are delivered to the site as prefabricated panels containing all electrical, plumbing, and heating equipment ready for connection. Kitchen unit is set up almost as easily as you plug in your radio. Whole bathroom comes as a unit. Plastic floors are cushioned on warm air space over concrete pad. A compact heating system makes costly cellar excavation unnecessary; chimney needs no heavy foundation.
Exterior of house requires no point

PREFABRICATED PARTS MAKE CONSTRUCTION EASY



YOUR LIVING ROOM . . . TOMORROW

The television screen is the focal point in the living room. Radio controls are located strategically in the furniture. Illumination is from an indirect fluorescent cove and specific ceiling sources. Ventilating louvers above and below plate-glass windows leave unbroken vision at all times

calls for. Your new windows will be double-glazed, with dead-air spaces between the panes for insulation against both heat and cold. If you wish, they may be for vision only, with concealed, screened, adjustable louvers at top and bottom for ventilation. For other windows, which may be opened horizontally to their full width, there will be complete weather stripping and screens. With both types will come filters for pollens.

Radiators and registers, you will be glad to know, are to give way to piping within the walls of your house. Installation costs, which will be somewhat higher, will be offset by a fuel saving of one third of present average heating costs. Heating systems will incorporate air-conditioning. In other words, you will have humidified winter heat thermostatically controlled, and summer cooling with proper circulation of dry, filtered air. Windows need never be opened. Your heating will be automatic, of course, whether you use coal, coke, gas, or oil. Where there is cheap hydroelectric power, electricity will not indirectly heat your home by means of hot water or steam, but will work directly through heating elements within the walls and floors, integral with the prefabricated sections.

Since postwar heating systems will be small and compact, space on the ground floor can readily be found for them. So, in planning your house of tomorrow you may write off a large part of the expense of digging a cellar and building waterproof cellar walls, for with advanced types of floor construction, new chemical ground treatments, and the use of copper shields, the dangers of damp and of termites are eliminated. Only small footings will be required. Many houses will be built on precast concrete slabs which will contain pipes for floor heating.

Your house may also be soundproof. Rooms will be so insulated from each other that your sleeping will be undisturbed by the noise of the late party downstairs. Radio installations and television devices will be in each room.

Even more revolutionary than the changes already mentioned will be your all-metal or all-plastic kitchen built in one unit, and capable, in whole or in part, of removal and trade-in, like an automobile.

Ranges will have lighted, transparent oven fronts. Time and heat control will have been developed so that before the lady of the house goes out for the afternoon, she may put the whole dinner on the stove. Time-controlled to start cooking at a determined time, the dinner will be ready to serve on schedule. If she is late in returning, nothing will burn, for the heat will be automatically reduced to warming temperature at a set time.

The real revelation, however, will be your refrigerator. It is likely to be a plastic cabinet with transparent doors, and a cylin-

drical revolving interior. No hunting in dark recesses for the elusive butter; you switch on a light, turn the shelf levers until the butter dish appears up front, and then open the door to that particular shelf by flipping out a concealed handle, or stepping on a convenient pedal, or by knee action against a button. Ice cubes will be dispensed individually by pressing a button. Cracked ice will be available in the same manner. These ice dispensers will be separate from the main cabinet, so that no cold will be lost in removing the ice. Within the refrigerator, a reservoir connected with the water pipes will furnish cold water uncontaminated by near-by foods.

In your house of the future there will be devices for both the freezing and the dehydration of your surplus garden foods, and means will be provided for their proper storage. Ultraviolet-ray tubes placed at strategic places in the kitchen will kill harmful bacteria in the refrigerator, prevent mold in the bread box, and sterilize dishes.

The same fine engineering will mark the unit bathrooms and lavatories of your home. In many cases these will come in the same unit with the kitchens, back to back, on one wall, to reduce plumbing lines to a minimum. Or they may come in double bathroom units. Your shower will have sliding nonbreakable plastic walls. You will be able to set the temperature for your bath, and the water will mix itself. Condensation units within both the shower and the tub enclosures will eliminate steam, and low-voltage units behind mirrors will prevent condensation on them. *(Continued on page 215)*

YOUR BATHROOM, KITCHEN . . . TOMORROW

Gone are the ugly crocks of our tile bathrooms, for the plastic fixtures are integral with the wall and floor. Rounded outlets replace protruding faucets. Pedal buttons control water supply for basin and toilet flush. The floor is a heat chamber; the ventilator fan is humidistat controlled

Plastic kitchen unit. Left to right: Refrigerator with transparent doors which open by knee pressure on large buttons; ice and water unit. Garbage ejector. Sink, flanked by dish washer and sterilizer; in front center, towel drier; below, floor pedals operating sink outlets. Right, automatic range with transparent oven doors. Floor of indestructible plastic. Note sun visors

NEW Tools

ADJUSTABLE MIRRORS, looking like large-scale models of a dentist's mirror, aid aircraft workers in examining hard-to-get-at parts. Made by F. P. Kretchmer, of Los Angeles, the plastic-mounted mirrors have a handle sleeve which allows adjustment to any angle.

TWO-HAND SOLDERING is made possible with this stand, which is fitted with an adjustable, but firmly held, soldering iron. A magnifying lens is located in the hood, which can be raised or lowered, and a 30-inch chimney carries off the fumes. The manufacturer is Photobell Corp., of New York.

CHIP-BREAKER GRINDERS, made by the Delta Manufacturing Co., of Milwaukee, are equipped with a universal vise to hold work at any angle. A long spindle with widely spaced bearings permits precise alignment.

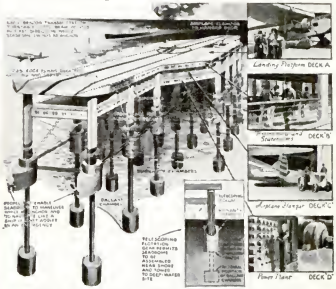
MOTORIZED SWEEPERS developed by the Moto-Mower Co., of Detroit, enable a single worker to clean up a fair-sized plant at the rate of 16,000 square feet per hour, thus releasing a crew of broom sweepers for more important work. With minor adjustments, the machine can double as a lawn mower or a snowplow.

THE postwar construction of mile-long floating airports, which will be spotted every 800 miles along an air route between an East-Coast American port and Great Britain, has been announced by Pennsylvania-Central Airlines. These airports, designed by Edward R. Armstrong, of Philadelphia, Pa. (P.S.M., Feb. '34, p. 26), will cost about $10,000,000 each. By permitting transatlantic freight and passenger planes to refuel, they will make possible larger payloads. It is expected that they will cut passenger rates to six cents a mile.

At right, a reproduction of the leading page of an article which appeared in P. S. M. over nine years ago, and which described in detail the proposed airports

UNCLE SAM ASKED TO BUILD

Floating Ocean Airports



This illustration shows the design and construction of the latest model of the Armstrong seadrome which the Government recently was reported ready to try out. Note the arrangement of the four decks

REDUCED and improved since its earlier forms, were described in this magazine a new type of "seadrome" or floating airport is proposed by Edward R. Armstrong, of Philadelphia, as the basis of a modernized plan to bridge the Atlantic with a string of artificial islands. His project, which has attracted the interest of U. S. Government officials, calls for a regular twenty-hour passenger service between America and Europe. It calls for the anchoring of five of the artificial islands between America and Spain at about the latitude of Bermuda, and the Azores, and providing stations about three hours flight apart. Planes using these islands as stopping-point fashion could transport heavy pay loads at high speed since their loads of gasoline would be light.

On these pages our artist shows the details of the latest type of seadrome proposed by Armstrong, in which he has cut left his previous "Ark" (Feb. '34, p. 26) to a single deck, supported 100 feet above the water on twenty-eight submerged buoyancy tanks, would not pitch and toss in stormy weather, Armstrong declares. Because its supporting buoyancy tanks are submerged, it would be subject to wave motion and its upswept structure allows waves to pass unhindered beneath its decks. These facts he has verified by experiments with models. Because of its size, the seadrome would have accommodations for 100 travelers in addition to quarters for its usual crew and hangar space for fifty large transport planes. Rooms for the crew would include a dining room, officers' mess, second officers' mess, and engineers' as well as two dormitories and a gym.

Any type of plane—land plane, seaplane, or amphibian—could use the seadrome as including stations, although Armstrong himself believes that a special-

Landing area of seadrome compared with that of an aircraft carrier. Broken lines show the time part that is to be built

POPULAR SCIENCE MONTHLY

Putting more punch in our fighting planes

Flying Gun Carriers

By Arthur Grahame

AIRCRAFT ARMAMENT HAS COME A LONG WAY SINCE WORLD WAR I . . . AND STILL THE TREND IS TOWARD HEAVIER, MORE CONCENTRATED FIRE POWER

TOMORROW'S decisive air battles will be won by toughly armored flying gun carriers packing a weight of fire power far greater than that of the most gun-bristling fighter planes of today.

Aircraft designers and builders of all the major powers are engaged in a breakneck industrial race, trying to satisfy the armed forces' insatiable demands for stronger, better-protected planes, and heavier, more destructive guns to mount in them. Some types of planes already are firing projectiles powerful enough to smash light tanks and motor transport. Bigger guns are being tried out experimentally, and some students of ordnance predict the emergence of an air-cruiser type armed with guns of three-inch caliber or larger, possibly embodying rocket principles or some other means of fire capable of overcoming the serious problem of recoil.

In short, the science of aircraft armament, born in the First World War and more or less stagnant in the 20 years that followed, is now moving ahead again at full speed under the insistent pressure of a bigger and tougher war.

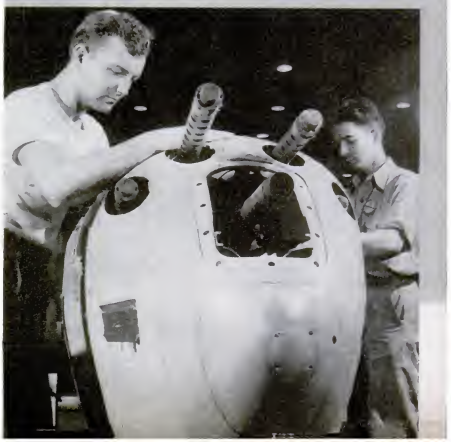
Even in this air-minded day, few Americans realize how greatly airplane fire power has been boosted. The one-place fighter plane offers a good basis of comparison. By 1918, in the closing period of the war, both sides had settled on a main fighter type armed with two rifle-caliber machine guns attached to the fuselage and fitted with synchronizers enabling them to fire through the propeller arc without damaging the blades.

With that armament a pilot who managed to line up an enemy in his sights for a reasonable burst—say five seconds—could pepper the foe with about 166 bullets having a total weight of four pounds. Just before the outbreak of this war the most heavily armed fighter plane in service was the British Hurricane, with eight .303 caliber machine guns firing from the wings. The same five-second burst from these ships delivered around 800 bullets, weighing 20 pounds—or 400 percent more weight.

One of the most heavily gunned planes on fighter duty in Europe today is the Royal Air Force's Spitfire IX, which goes into action with four .303 caliber machine guns and two 20-mm. automatic cannon spitting lead, steel, high explosive, and destruction. In five seconds the ship can fire 400 machine-gun bullets and 120 20-mm. armor-piercing or high-explosive shells. The total weight of the blast runs around 45 pounds—more than eleven times that of the 1918 plane.

That kind of development in fire power is the logical outcome of a corresponding development in the armor protection of the bombers which are the fighter's natural

FIVE GUNS GIVE THE P-38



HOW FIRE POWER HAS GROWN

1918 Two machine guns mounted on a fighter's fuselage could deliver about 166 bullets in five seconds

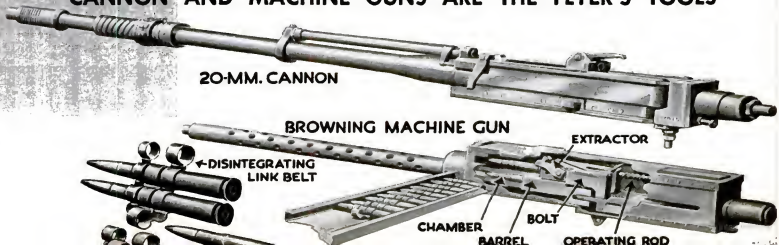
1939 Hurricane's eight wing-mounted guns peppered a foe with something like 800 bullets in a five-second burst

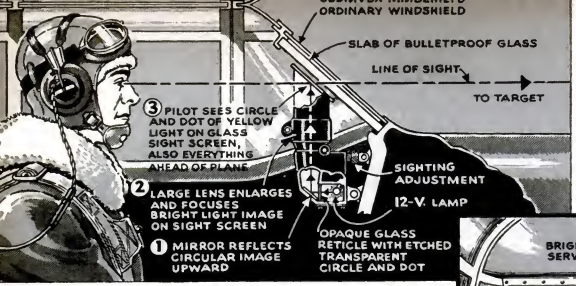
1943 Four .303 machine guns and two 20-mm. cannon on the Spitfire IX can put 400 bullets and 120 shells in a target within five seconds

ITS STING

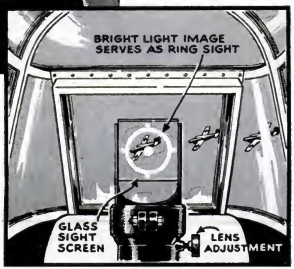
Twin-boom design of the Lockheed Lightning simplifies the placing of the guns. Four machine guns are arched over the 20-mm. cannon in the nose, where there is no propeller problem

CANNON AND MACHINE GUNS ARE THE FLYER'S TOOLS

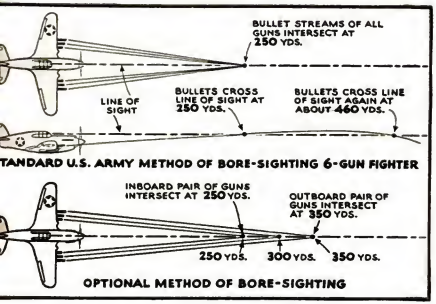




Improved sight has given fighter pilots a longer effective range. Since guns of a single-seater are aimed by turning the plane, sights must be fixed to the craft. The optical sight at left and below uses a circle of light that helps a pilot gauge distance of target



SIGHTING FIXED GUNS



Bore-sighting of fixed guns focuses fire power at a definite point, and it's the pilot's job to put the enemy on the spot. If the plane carries a cannon as well as machine guns, it is considered good practice to fire with machine guns until bullets hit target, then cut loose with the bigger stuff

enemy and prey. The rise of air warfare has brought about a repetition in this field of the long-standing race between ordnance and armor plate in naval design. As usual, gun power seems to have the edge, yet the ability of some new bombers, especially the American heavy types, to absorb punishment and shoot back has proved a painful shock to many an overconfident Axis fighter pilot.

The first military aircraft were not armed at all. The top commanders in 1914 re-

ALLIED PLANES USE 40-MM. AND 20-MM. CANNON

The R.A.F.'s tank buster, the Hurricane II-D, packs a 40-mm. cannon under each wing. Designed for aircraft use, the guns weigh 320 pounds each

For lighter work, a 20-mm. gun is used. Here a ground-crew member is replacing the magazine of a cannon in the wing of a Spitfire at an English fighter station

AERIAL GUN VS. BOMB For strafing small ground targets such as tanks and communications, airborne cannon have certain advantages over bombs. Perfect timing is essential to accuracy in bombing, but the plane's cannon can pump shells into its target as long as the ship is pointed at the mark. Greater speed and flexibility of maneuver are possible

garded their planes as observation devices, somewhat more mobile than captive balloons but no more aggressive. Individual pilots took the initiative by carrying carbines, pistols, or shotguns aloft and potting away at enemy ships that ventured within range.

The next step was to mount a light machine gun on the ship, and the simplest arrangement was to have the gun on a swivel to be operated by the gunner in a two-place plane. But single-seater ships had far greater speed and maneuverability, so it was clear that the ideal fighter would be one in which the pilot could do his own shooting, aiming the entire plane at the target and firing the fixed gun by remote control.

A gun bolted to the center of the upper wing could fire above the propeller arc, but it created wind resistance and forced the pilot to stand up if he had to clear a jam or change ammunition pans. This arrangement was superseded by the development of the first practical synchronizer by Anthony Fokker, Dutch aircraft manufacturer.

Fokker's device consisted of a cam mechanism placed between the airplane engine and the machine gun's action. It was a tricky, cranky gadget, but when lined up and adjusted with loving care it worked, by restricting the gun's discharge to the brief instants when the propeller blades were in a horizontal position and out of the line of fire. The Germans had the inside track on Fokker's invention and enjoyed a brief advantage—until British and French engineers duplicated the device.

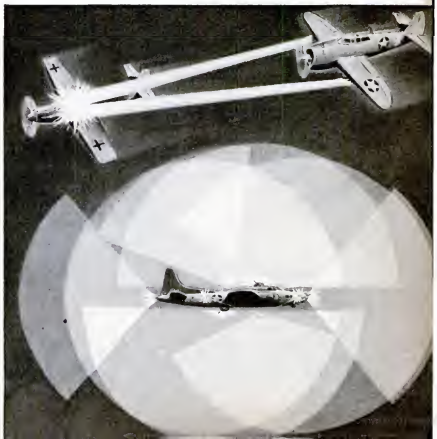
Both sides continued to experiment with new ideas in aircraft weapons, but the synchronizer was the only development that really made itself felt in actual combat. All efforts to mount heavier guns, for example, were inconclusive. The British started work on an automatic one-pounder cannon, but the war was over before much progress had been made with the design. In 1917 the French Hispano-Suiza company brought out a short-barreled 37-mm. gun mounted in the notch of a V-type engine and firing through a hollow propeller hub.

This gun was a single-shot type, and thus completely lacking in true air fire power, but its mount was exceedingly well thought out, and variations of it are used today in cannon-firing planes.

The Germans, meanwhile, had worked on

FIXED OR FLEXIBLE GUNS?

Fire power of fixed guns on fighter planes is concentrated into a slash of steel in front, where the pilot controls it by maneuvering. Flexible guns, as on the bomber pictured below, give varying degrees of protection in all quarters. The fixed gun is primarily for offense; the flexible, for defense



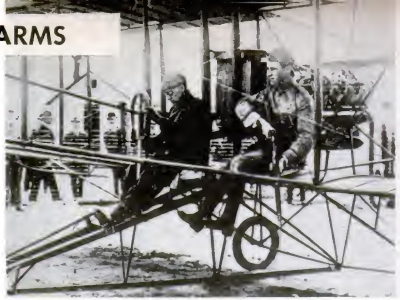
a Becker 20-mm. gun with a 12-shot magazine. It never was very successful, and after the war the owner sold out his patents to the Swiss Oerlikon firm. What happened later is an interesting example of how military designs circulate. Oerlikon continued to develop the design, and later sold patent rights to Hispano-Suiza. The French firm, in turn, passed its designs on to the British. Later the United States took it over, modified and improved the design, and is now using a so-called Hispano 20-mm. in some versions of the P-38 Lightning and P-39 Airacobra fighter planes. The Germans also have a short-barreled Oerlikon FF model, but are known to be replacing it with a high-velocity Mauser 20-mm. gun.

Our own ordnance experts carried on numerous experiments during World War I, one of them involving the Davis "no-recoil" gun, an unconventional weapon of about 2¼-inch bore. It was recognized that the element of recoil was one of the biggest limitations to the firing of powerful guns from aircraft. The Davis gun tried to solve this by discharging a dummy slug or a load of shot backwards from its elongated breech at the instant the actual projectile was fired from the muzzle, so that the counteracting forces balanced each other and eliminated recoil at the gun's mount.

Army ordnance even considered using a five-inch gun of this type, but after thorough tests the Davis gun was discarded, mainly because it could not be aimed quickly and because the breech discharge was found to be just about as dangerous to near-by friendly aircraft as its projectile was to the enemy. Later a light 75-mm. mountain howitzer was prepared for plane mounting, but was never test-fired.

America's greatest progress, however, was made in the development of specialized aircraft machine guns, and the pioneer work was carried out by our "gun wizard," the late J. M. Browning, probably the world's greatest designer of automatic weapons.

Browning, the designer of the entire family of machine guns used by the U. S. armed forces, first concentrated on a .30 caliber aircraft machine gun, and produced a 22-pound, air-cooled weapon with a rate of fire of 1,200 shots a minute. It snaps out 150-grain bullets (about 47 to the pound) with a muzzle velocity of 2,750 feet a second. The same Browning design in a .303 caliber ver- *(Continued on page 212)*

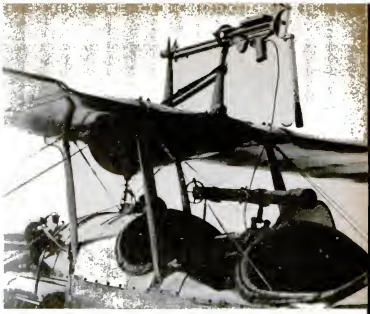


FIRST GUN to be fired from a military airplane was a rifle in the hands of Maj. T. E. Fickel, U.S.A., in 1910. Aircraft's rôle seemed to be unarmed scouting

SYNCHRONIZED GUNS to fire through the propeller were a World War development. This is a Vickers aircraft machine gun mounted on a U. S. Navy airplane

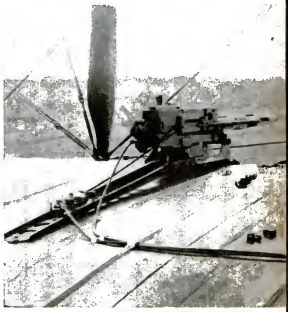
WAIST GUNS were not unknown in First World War days, as this well-armed U. S. Navy flying boat testifies. The man on the wing is using an early turret

FIRST MACHINE GUN in the air also was a U. S. achievement. Here Capt. C. DeForest is taking a Browning ground gun aloft in a biplane in 1912



FIRING OVER WING. This fighter plane of World War I has a Lewis machine gun fixed atop its upper wing. It fired above the propeller arc

TURRETS and flexible gunnery were foreshadowed by this World War mounting of a Lewis ground machine gun. Power-driven turrets made their initial appearance about 10 years ago



WING GUNS came along with post-war experiment. This is a Browning .30 caliber on a U. S. Army plane (1925)

FLEXIBLE GUNS have taken many forms in the course of their development. Below is a swivel mount that was tested experimentally by the Navy in the search for higher efficiency

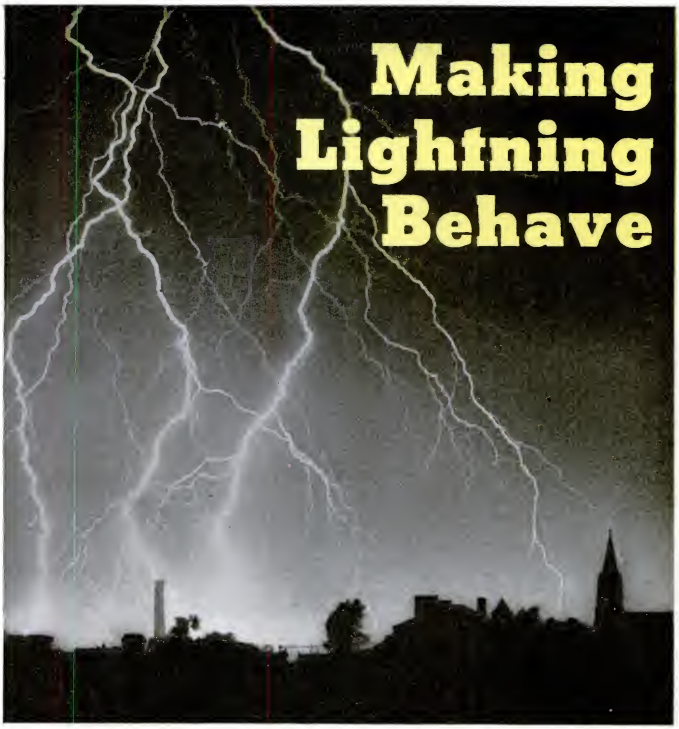
DAVIS CANNON fired a dummy load backward to eliminate recoil. Lewis gun atop this one helped to get the aim

World's Largest Building Cooled by Sun Control

Drawing by B. G. SEIELSTAD

ROOF UNITS
ELECTRIC PHOTRONIC CONTROL RELAYS—MAXIMUM AND MINIMUM UNITS
ELECTRIC PNEUMATIC RELAYS
MASTER CONTROLLER IN AIR INTAKE
HEAT-SENSITIVE ELEMENT
AIR STORAGE TANK
DEHUMIDIFIER (IN ATTIC OF BUILDING)
FRESH-AIR BY-PASS
DAMPER
WATER SPRAY
PAN
DAMPERS
FAN
DAMPER CONTROL UNITS
COMPRESSED AIR AT 15 LB. PER SQ. IN. FROM BUILDING SUPPLY
PUMP
COLD-WATER VALVE
SUB-MASTER CONTROLLERS
CEILING DUCT
ADJUSTABLE COVER
BLUE SCREEN
POLAROID FILTER
PHOTOELECTRIC CELL
ROOF UNIT
LOCATION OF ROOF UNITS ON PENTAGON BUILDING

THE sun cools, as it heats, the Army's Pentagon Building in Arlington, Va., (P.S.M., Feb. '43, p. 49). Passing over the vast roof of the world's largest building, its rays fall upon photoelectric cells in five roof-top control stations. Registering the temperature rise, each of these stations in turn, by means of electronic relays and compression tanks, activates the fans of the cooling system. Designed by the Minneapolis-Honeywell Regulator Company and Charles S. Leopold, consulting engineer of the War Department, the system maintains a temperature of 77 degrees.



Making Lightning Behave

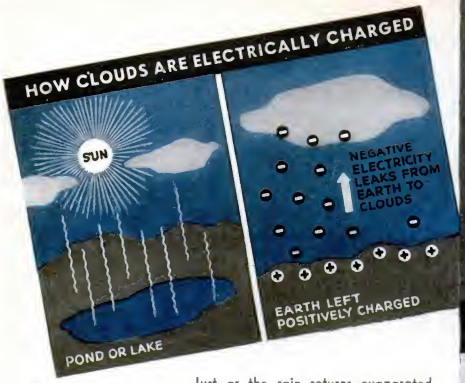
Newly discovered facts about nature's fiery blitz help to guard vital power lines and keep war plants humming.

WHEN your electric lights used to go out, during a thunderstorm, it was just one of those things that couldn't be helped. Nowadays, they stay on. More important, power interruptions that once wrought costly havoc in industrial plants have been virtually ended. Electric motors that turn the wheels of vital war industries keep on humming.

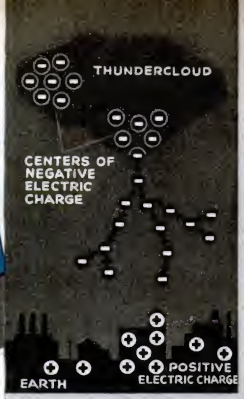
Engineers have learned how to tame lightning. Primarily their aim has been to safeguard electric service. But their researches have found equally practical application in protecting persons and buildings from nature's pyrotechnics. Weather forecasting and aerial navigation, too, have shared the benefits.

Using a high-speed camera in South Africa, a modern pioneer, B. F. J. Schonland, has literally turned upside down the popular conception of a lightning stroke—and added fascinating embellishments for good measure.

Only tall masts and skyscrapers, he finds, get hit by bolts from the clouds. Between low objects and a cloud, a lightning stroke actually travels upward! But a path has already been made for it by a hitherto unknown kind of downward electric discharge



Just as the rain returns evaporated moisture to earth (left), lightning returns electricity leaking up to the clouds at the rate of 300,000 kilowatts



1. "Pilot streamer" traveling at 500,000 feet a second, starts toward positively charged earth

that he describes as a "pilot streamer."

From a negatively charged center at the base of a thundercloud, the faintly luminous pilot streamer launches itself at the positively charged earth at the comparatively leisurely speed of about 500,000 feet a second. As if to hammer it along, stronger and faster-moving electric discharges, called "step leaders," pulse down to its advancing tip in rapid succession. The combined effect ionizes, or makes electrically conductive, a pencil-thin path through the air.

When the pilot streamer reaches the earth, the fireworks go off. Back along the path it has blazed, to the cloud, crashes the dazzling flash that the man in the street calls lightning. If the pilot streamer has branched on its way to earth—as it is likely to do over uneven terrain—the return bolt follows out and neutralizes the branches as well as the original charge center in the cloud. The brilliant discharge travels at about 100,000,000 feet a second, or less than one seventh of the speed of light.

Quite likely the performance has not ended. Another charge center in the cloud may "short-circuit" to the path already set up, and launch a nonbranching "dart leader" to earth, evoking a second lightning flash in response. This continues until the cloud is wholly discharged. As many as 22 successive strokes have been observed in a multiple flash. Since the entire exchange takes place within a fraction of a second, and all discharges follow exactly the same path, the series appears to the eye as a single flash.

A tall structure like New York's Empire State Building, in contrast, usually launches a pilot streamer at a thundercloud and receives a bolt of lightning in return. The steel framework carries off the stroke harmlessly to earth.

Tests with man-made lightning in high-voltage laboratories confirm the new discoveries about natural lightning. For most practical purposes, it has

Man-made lightning, directed at this model house, is shown being harmlessly diverted to earth by Dr. McCann's lightning "umbrella." At far left, the same model, when struck without umbrella protection, instantly bursts into flames

2. When streamer hits the earth, lightning flashes back along same path at 100 million feet a second

3. Second negatively charged area, unaffected by the first flash, now "short-circuits" to positive area

4. Following path already set up, second area sends "dart leader" to earth—to evoke a second flash

been found, skyward and groundward thunderbolts differ little in effect. Therefore it remains customary to speak of lightning as striking the earth—a convention that will be followed in this article—even though the opposite may be the fact.

On the whole, thunderbolts do far more good than harm. A stroke of lightning captures nitrogen from the air, "fixing" it in beneficial compounds that raindrops bring to earth. The result is to shower all growing plants with more fertilizer than the combined output of all the factories in the world.

True, there are fifth-column lightning bolts, too—but science is showing how to cope with them and disarm them. A "lightning locator" under recent development reveals the course of an oncoming electric storm as accurately as secret war instruments plot the approach of raiding planes. This enables workers in an ordnance plant to keep up full-speed production until the last moment, when the storm enters a precalculated danger zone surrounding the factory. Then the personnel leave the buildings, and return only when the thunderstorm has reached a safe distance.

How far is a safe distance? By measuring electric and magnetic fields around a lightning bolt, experimenters recently have discovered that it need not score a direct hit to start a fire or cause an explosion. A "near miss," as in bombing, may prove as effective. Tests show that a lightning stroke as far as half a mile away may induce a small electric spark between near-by metal objects. Hitherto unexplained fires in wooden barns are now believed to have been started in this way.

A man driving a modern steel-top car in a thunderstorm is in about the safest place he could be. Its metal body almost completely encloses him in a "Faraday cage," proof against exterior sparks. Any doubt on this score vanished from the minds of spectators who watched Dr. Gilbert D. McCann, Westinghouse lightning expert, seat himself at the driver's wheel of a standard car and submit to a 3,000,000-volt bombardment of man-made lightning from a sphere above. Harmlessly the flash leaped from the metal work over one of the front tires to the ground.

"Lightning umbrellas," recently designed by Dr. McCann, are believed to represent the first radical departure from conventional lightning rods in nearly 200 years. These are intended especially for ordnance plants and oil storage centers, and a number of large-scale installations have already been made.

The simplest plan consists of stringing a single length of steel wire, resembling a radio antenna, above the entire length of the building. From wooden poles that support the horizontal wire, its ends are then brought to earth and grounded. An alternative scheme surrounds the structure with a series of masts bearing projecting and grounded wires. The number of masts varies according to the area to be shielded. How well the systems work has been amply demonstrated by subjecting models to re-

peated strokes of laboratory lightning.

For farmhouses, barns, churches, and other "nonhazardous" buildings, experts agree that the time-honored lightning-rod system still offers first-class protection from lightning, assuming it to be properly installed and grounded. How this should be done is explained and illustrated in Farmers' Bulletin No. 1512, available for five cents from the Superintendent of Documents, Washington, D. C. Copper wire as large as No. 2 A.W.G. (about one quarter inch in diameter) was often used throughout, in prewar days of plenty. Tests now show wire of this size to be needed only where it is likely to be struck directly and burned by lightning. The rest of the system may employ No. 6 A.W.G. wire (about one sixth inch in diameter) to conduct the lightning current safely between these points and the ground. The smaller size saves 60 percent of the copper formerly employed.

Heaviest of all recorded thunderbolts, Westinghouse engineers say, was one that struck a 585-foot smelter stack at Butte, Mont., in the summer of 1940. Its current totaled more than 160,000 amperes of electricity, delivered at a pressure exceeding 15,000,000 volts. Nevertheless, it did no damage, for it streaked to earth along a prearranged channel, writing its life history on the way.

Called a "fulchronograph," the instrument that has measured the power of this and many other lightning strokes applies the principle that hard steel will be permanently magnetized by current passing through adjacent coils. In practice, two coils carry a portion of current diverted from the lightning stroke being measured. Rotating past them, an aluminum wheel bears 408 steel fins on its rim. The particular fin that happens to be passing the coils at a given instant is magnetized in proportion to the punch of the lightning, during 40/1,000,000 of a second. Then the next fin takes over the recording, and so on. Studying the pieces of steel at their leisure, Westinghouse men are able to reconstruct both the duration of the bolt and its variations in strength from one instant to the next.

Dr. Gilbert D. McCann, one of the developers of the instrument, is shown at right examining a fulchronograph. Porcelain column at left is a lightning arrester, which guards power lines by grounding any lightning that may hit them

Grounded shielding wires, erected parallel to power lines, now intercept lightning strokes and guide them to earth before they do harm. Foot-high models, exposed to 15,000 strokes of artificial lightning, showed the best place to put the shielding cables—above and at an angle of about 30 degrees outside the power lines. Most troublesome are low-flying thunderclouds, about 500 feet from the ground, which have the best chance of flinging a sideward bolt that will "duck" the protective wires. Many lighting bolts, on the other hand, originate in clouds five miles high.

Today, about 6,000,000 lightning arresters stand guard over the nation's power lines, just in case lightning actually does strike them. The smallest, no bigger than cigarette lighters, protect railway signal lines and fire-alarm systems. The largest, 30 feet high, guard huge generators in hydroelectric plants—and are "earthquake-proofed" by being suspended from cables above the earth. These arresters act in the same manner as safety valves.

Automatic circuit breakers, serving like switches to open and close a circuit, provide the final line of defense against a lightning stroke on a transmission line. In your home, a fuse or a small switch will shut off the electricity, because the power passing through the wires is relatively small. But in power stations and substations where the power is high, neither fuses nor even big switches will do. In case of a short circuit or a surge of current caused by lightning, the power would get out of control, and leap through the air in a destructive arc.

A new circuit breaker developed by Westinghouse engineers literally blows out this electric fire with a blast of compressed air exceeding the 750-mile-an-hour velocity of sound, while pistons yank the metal contacts apart. Another type snuffs out the arc with magnetic force. Superseding conventional breakers, immersed in tanks filled with insulating oil, the new designs save steel and oil for war use.—ALDEN P. ARMAGNAC.

Tricks with Figures

By E. J. DINTRUFF

VARIETY is also the spice of figures. If numbers seem dull, very likely you have approached them in the same unvaried way too long. Try these strategic attacks.

In multiplying by five perhaps you subconsciously annex a cipher and then divide by two. But do you know that to multiply by 25 you may add two ciphers and divide by four; or to multiply by 125 you add three ciphers and divide by eight?

To multiply by 11, annex a cipher and add the original to the newly formed. Or put down the last digit of the original number, then to the left place the sum of each digit plus the one to its left, setting down each time only the unit figure, and carrying the figure representing the tens. Multiplying by 111 can be done in a similar manner. (See below.)

To multiply by nine, place a cipher before and after the number. Now subtract each figure from that to the right of it, taking care to borrow when the next figure is too small.

At times, multiplying is an easy way of dividing. Just as to divide by five you may multiply by two and set off the last figure by a decimal point, to divide by 25 you can multiply by four and set off two figures. Similarly, to divide by 125, multiply by eight and set off three places.

In adding, attack a double column on the left flank instead of the right. Add the figures on the left, put down that representing the tens in your total; to that representing units, annex a cipher and add the figures in the right column. Put the results to the right of the figure already set down.

The same left-flank approach can be made to subtraction. Keep glancing ahead one column to allow for borrowing. Subtracting 72931 from 89068, take 7 from 8; then 2 from 8 (since one must be saved for borrowing); 9 from 10; and so on.

18	9	6	3	2	1
18	9	6	3	2	1
19	10	7	4	5	4
20	11	8	5	8	7
21	12	15	12	11	10
22	13	16	13	14	13
23	14	17	14	17	16
24	15	24	21	20	19
25	16	25	22	23	22
26	17	26	23	26	25

Figures are fun, too. Let a friend choose a number and tell you in which of these columns it may be found. Add the numbers at the heads of the columns he designates and you get his number. (From "Mathematical Recreations," by Maurice Kraitchik; W. W. Norton & Co., New York)

137 ÷ 125

Ⓐ MULTIPLY BY 8

137 x 8 = 1096

Ⓑ SET OFF LAST 3 PLACES

= 1.096

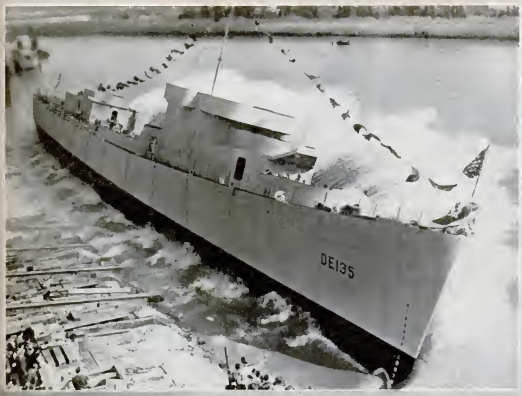
57263 x 111 =

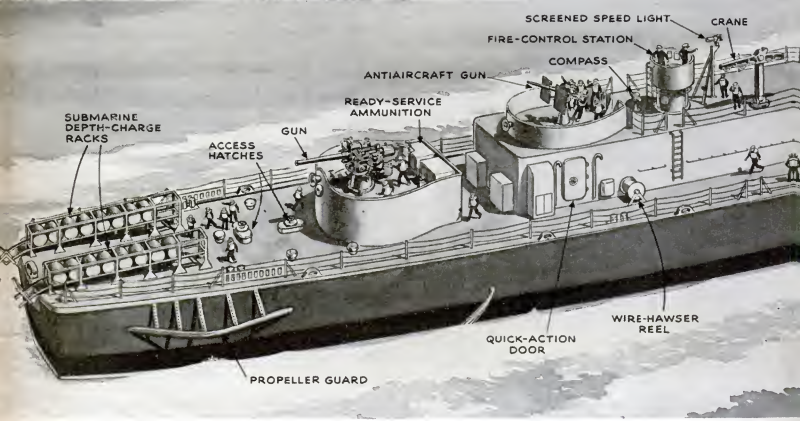
Ⓖ Ⓕ Ⓔ Ⓓ Ⓒ Ⓑ Ⓐ

(5+7)(5+7+2)(7+2+6)(2+6+3)(6+3)

6 3 5 6 1 9 3

To divide by 125, multiply by eight and set off three places. To multiply by 111, set down the last digit, then the sum of the last two, that of the last three, then the next three, and so on





Why "DE" Boats Are Death

CLEAN-LINED and businesslike, Uncle Sam's new destroyer escorts (P.S.M., July '43, p. 110) are pounding the high seas in good weather and bad, helping to crush the submarine menace and maintain the vital flow of troops and munitions to the theaters of war.

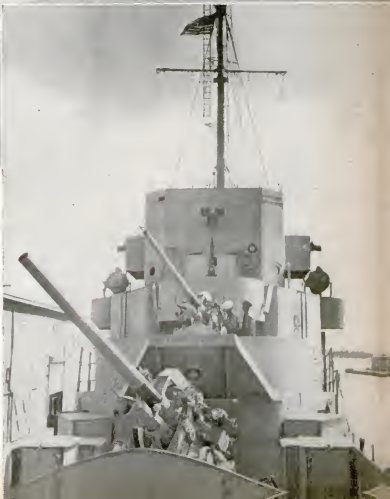
A comparatively new type of vessel for the U. S. Navy, the 1,300-ton DE is a highly developed cross between the British corvette (which U. S. Navy men rate as too slow and too lightly armed for general use) and the standard destroyer (which is complex, costly, and slow in building). The DE combines a fair amount of the destroyer's speed and hitting power with the corvette's simplicity, low cost, and speed of production; it is an ideal warship for protecting merchant-ship convoys. Each DE has dual-purpose guns and depth charges to fight sub-

SIGNAL YARD
ANTENNAE
RADIO DIRECTION FINDER
SIGNAL-FLAG BAG
SIREN
OPEN CONTROL STATION
BELL
SEARCHLIGHT
ANTIAIRCRAFT GUN
BRIDGE
GUNS
VENTILATOR
ANTIAIRCRAFT GUNS
TORPEDO TUBES
STACK
LOADING MACHINE
DE162
MOTOR LIFEBOAT
LIFE RAFT
FUELING HOSE
SIDE LADDER

to Subs

marines, machine guns and antiaircraft guns to beat off low-flying planes, and torpedo tubes for use against surface raiders.

Our drawing by Stewart Rouse illustrates construction and equipment. Official U. S. Navy photographs show (upper left) one of the scores of new DE's sliding off the ways of a Texas shipyard and (lower right) dual-purpose and AA guns as seen from the bow of another of the novel craft.



GERMAN PILOTS RENAMED IT: "Gabelschwanz (FORK-TAILED

Our P-38 Lockheed Lightning has taken on the best in the Axis stables . . . and proved it's a lot of plane in any language

By ANDREW R. BOONE

THE U. S. Army prosaically called its new fighter-interceptor "P-38." Lockheed Aircraft engineers and test pilots called it "Lightning," and that name stuck with the combat pilots who flew it. And now the Germans have a word of their own for this twin-engine, twin-boom aerial destroyer. Nazi pilots shot down and captured in recent operations bitterly referred to it as that *"Gabelschwanz-teufel!"*—fork-tailed devil!

But under any name at all, it's a lot of combat airplane—one of the fastest, highest-flying, hardest-hitting ships ever turned out. For all-around versatility and power the P-38 is in a class by itself. It has been used successfully as a fighter, interceptor, bomber escort, bomb carrier, low-level strafer and tank-buster, long-distance reconnaissance ship, and high-altitude photographic plane.

Performance on most of the major battle fronts has shown the Lightning to be equally effective flying from hastily carved-out jungle fields in the far Pacific, from cramped and rocky fields in the Aleutian Islands, from the sandy wastes of North Africa, and from the mist-bound runways of England. One of its most important services was to make possible American daylight bombing raids over Germany. The Lightnings provided fighter escort at high altitude hundreds of miles from the home bases, fending off enemy attacks over the target area for as much as an hour, then accompanying the bombers on the dangerous return flight and seeing them in to a safe landing.

P-38's didn't swing into action as soon as the United States was plunged into the war. Our enemies unquestionably knew that we had a ship of this unconventional design in the works, but they couldn't know much about its performance and fighting characteristics. Wise military strategy in a case like that dictates that the new weapon be withheld from action until it can be assembled at the proper places in quantities large enough to take maximum advantage of its surprise punch.

Squadrons of Lightnings were organized first in the Pacific area, then others were sent to England, and finally the plane emerged in North Africa as our main fighter type for that theater. The ship has been a thumping success in all three theaters of war.

Probably the first official combat involving P-38's was in the Aleutians, when the fork-tailed ships suddenly popped out of a cloud and shot down two Japanese K-97 four-engined flying boats and two escort fighters. Even more significant than the victory itself was the fact that this combat dispelled a notion that the Lightning was a high-altitude ship, unable to perform at lower levels. There isn't any high altitude to speak of in the fog-shrouded Aleutians.

Even more spectacular in result was the Lightnings' first battle with the Japanese in New Guinea. Twelve of the P-38's ran into a much larger enemy group, including some seven "Val" dive bombers and an escort of 25 or 30 fighter planes—"Zekes,"

Teufel"
DEVIL)
WHAT YOU SHOULD
KNOW ABOUT OUR
FIGHTING PLANES

"Haps," and "Oscars." (Zeke and Hap are the two current versions of the well-publicized Jap Zero fighter; Oscar is another fighter plane, the Nakajima 97.) The Lightning pilots shot down 15 enemy craft and damaged several others which probably didn't get back to their bases. None of our pilots were injured and only one of the planes was damaged.

The P-38 had another brilliant debut in North Africa, one squadron destroying 15 enemy planes in the first day's operations over the Gabés-Sfax area of Tunisia. Later the planes went on important ground-strafing missions and knocked out 11 tanks in two days, along with much enemy transport, including trucks, armored cars, and motorcycles.

The Lightning has fought it out there on even terms with the very hottest enemy fighter planes, among them the German Messerschmitt 109, 110, and 210, and the Focke-Wulf 190. American pilots swear by their ship, and vow it is the best pursuit job in action there.

This actual battle experience has served to dispel some of the doubts airmen and Army men felt about the P-38 design when it first

FIRE POWER. The P-38 carries its sting in its nose, with four .50-cal. machine guns clustered around a 20-mm. cannon. The result is a concentrated slash of bullets and explosive (lower left)

Here's what the 20-mm. cannon can do. In this test, projectiles have punctured a one-inch steel plate after passing through 20 inches of planking and 12 inches of sand to hit it

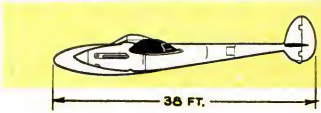
Teammate of the Flying Fortress: Long range of the P-38 enables it to escort the big bombers on their sweeping raids

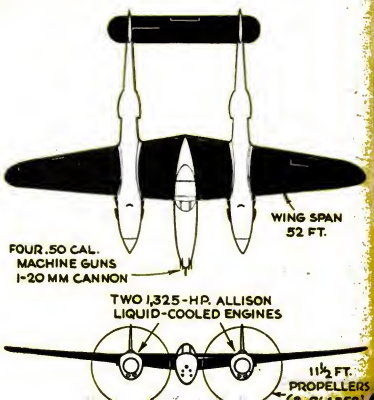
became known. To sum these doubts up: Wasn't it too big—"just too much airplane for one man?" Wouldn't it lack fighter-plane maneuverability? Would that open-work twin-boom construction have the strength to stand up and take the punishment of military operations? And wouldn't that same construction make it impossible for a pilot to get out safely in a parachute if the occasion arose?

The answers have come along fast under war conditions. The P-38 is beyond any doubt a first-class one-man fighter ship. As for its maneuverability, some of the American pilots in North Africa were so enthusiastic they told correspondents they could turn inside a Spitfire. Their testimony naturally must be taken with at least a grain or two of salt; other factors being approximately equal, the smaller and lighter airplane always should have greater maneuverability than the larger and heavier one. And the huskiness, power, and long range built into the Lightning must have required some slight sacrifice of other characteristics. Nevertheless, the battle performance of this P-38 against Germany's best ships is proof that it has maneuverability enough to play in the big league of air warfare.

The question of parachuting from the ship was tricky, but it has turned out that the trick can be done. A pilot can bail out either by flipping the ship over on its back and dropping from the open hatch, or by putting it into a stall and stepping back and down into the space back of the cockpit and between the twin booms. This may sound complicated, but it is not a simple operation to bail out of any hot ship, and the bailer always must follow a prescribed technique to avoid the fast-moving tail and elevator surfaces.

There remained the question of the ship's strength, and a big part of that was whether





the twin-motor arrangement wasn't a real weakness—just two things to get hit or go wrong. The growing list of Lightnings that have come in all right on one engine has set that point at rest; in fact, the climbing powers of the ship with an engine out of action have been a delightful surprise to more than one hard-pressed pilot.

As for the structural strength of the plane, startling proofs of that came in recently from battle areas half the world apart. Over New Guinea Lieut. Kenneth C. Sparks, of Blackwell, Okla., got into a tight dogfight with a Zero, and here is what he reported:

"Our right wing-tips hit, spinning the Zero around so that its propeller struck the trailing edge of my wing. He went down smoking and I kept on going."

Lieutenant Sparks admitted it was a tough jolt, but he was unhurt and his plane showed no damage except for a slight chewing up of that wing.

Around the same time, a group of Lightnings went out on a strafe in Tunisia, and pressed their attack home on one enemy airfield at such a low altitude that one of the ships knocked over a telephone pole. Capt. Mark Morne, of Hinsdale, Ill., in charge of the operation, reported laconically:

"Fortunately the accident only dented a wing of the plane, and he returned safely."

Airplane designers don't advise using their ships for disrupting enemy communications in quite such a direct manner, but it doesn't hurt pilot morale to know that you can get away with it if the occasion should arise.

Nothing very much like the P-38 had been tried out up until 1937, when the Army called in the nation's plane makers to study specifications for a new fighter aimed primarily to intercept any air raiders that might approach our coasts. Speed, range, and fire power were the prime requisites. The Lockheed company didn't have much military background, but Hall Hibbard, chief engineer, and C. L. Johnson, chief of design, thought they might have the answer in their private notebooks.

From the beginning they planned on a twin-boom, twin-engine ship. Twin engines would give added power and added safety, in case one power plant failed, plus better vision for the pilot and a chance to incorporate heavy gunpower in the nose without getting into the technical problem of synchronizing the guns to fire through a propeller arc.

Twin booms promised excellent control plus improved streamlining—a notion which worked out so well, by the way, that the present model, with its tricycle landing gear retracted, presents no greater drag than a card table 27 inches square.

The first ship began its flight-testing on December 30, 1939, and a few days later made a hop from California to New York in which it loafed along at never better than two-thirds throttle, made two stops for fuel, and completed the run in seven hours, 45 minutes. *(Continued on page 206)*

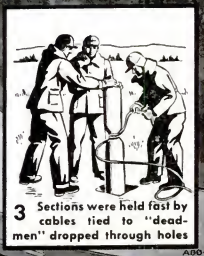
They're fighting for our allies, too. Here another Lightning, wearing the insigne of the R.A.F., flies to meet the best the Nazis can put up against her. The bulges on the tail booms are air scoops for cooling

"Sinking" a Floating Island

A LARGE floating island, 400,000 square feet in area and one to eight feet thick, was removed from a reservoir of the New York Power Corp. near Potsdam, N. Y., by cutting it up into sections and pushing them over the impounding dam. Cut while frozen, the 16 sections were held by cables until spring.

1 Hand ice saws cut through frozen ground to divide it into sections

2 After pilot cuts, power ice saw sliced through



3 Sections were held fast by cables tied to "deadmen" dropped through holes

ABBOTT GRIFFIN

ARMY GETS NEW SNAKE-BITE KIT

U. S. soldiers serving in jungle or desert country can give themselves immediate first aid, in case of snake bite, with a compact outfit being supplied to the Army by the Saunders Venom Extractor Co., Tarpon Springs, Fla.

Complete equipment for treatment of snake bite is contained in a water-tight plastic case 4½ inches long. The pump nozzles permit use on both large and small areas

1 Plastic container

2 Plastic pump

3 Suction nozzles

4 Tourniquet

5 Boric compresses

6 Ammonia inhalants

7 Lancet and cap

8 Iodine applicators

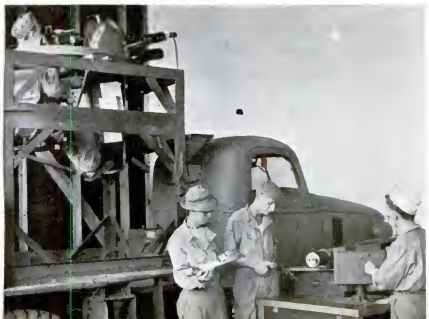
JUNGLE BOOTS, developed by Army officers working in collaboration with designers of the U. S. Rubber Co., are now being issued to our troops in place of regular G. I. leather boots, which have proved impractical in tropical climates because they disintegrate rapidly in damp weather, do not provide sufficiently sure footing, and are inclined to be uncomfortable. Camouflage-green canvas tops, designed to protect the ankles against tropical undergrowth, make it possible for the new boots to withstand repeated soakings and dry out quickly. Heavy, cleated rubber soles guarantee a firm footing even in mountainous regions. Equipped with duck insoles which are easy on overheated feet, the boots can be pulled on or off quickly by means of a special lacing—one lace for the instep and another for the legging, which also permits the boots to be worn partly open, providing ventilation when needed and adding to the soldier's comfort in hot climates.

RANGE-ESTIMATION trainers are teaching our air gunners exactly when to pull the trigger in actual combat. Looking through an iron-ring sight, the gunner, by means of a series of mirrors, is shown a model enemy plane. Mounted on a carriage, two of the mirrors are moved back and forth to make the model appear at distances ranging from 150 to 1,000 yards. Knowing the actual plane's wing span, the gunner, by a quick computation, determines how much of his sight the plane will fill at given distances. Trick is to tell when plane is at 600 yards—the best range for machine guns.

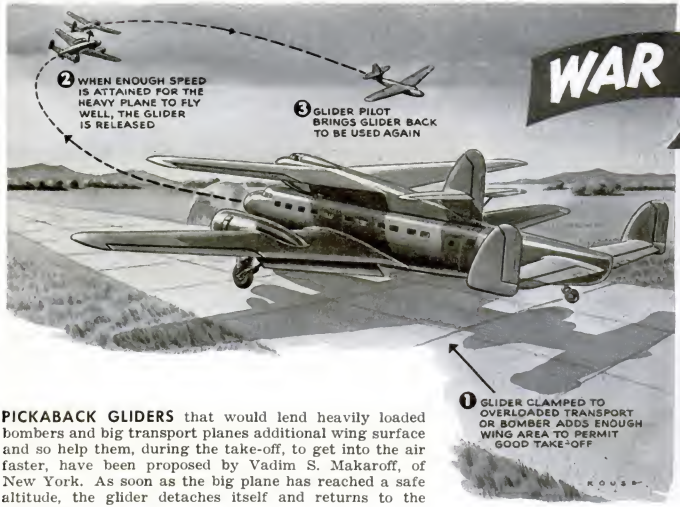
GROUND-TRAINING DEVICES TEACH FLYERS THEIR JOBS

Mechanical devices that save time, materials, and lives are used by the U. S. Army Air Forces Flying Training Command to prepare our air fighters for the test of actual combat.

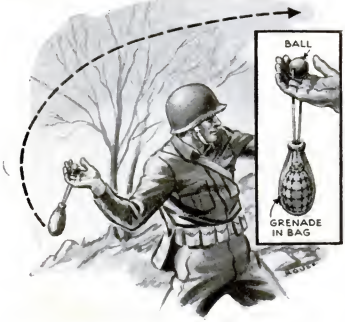
TRAINING FILMS, prepared by a special Army unit, are speeding up the education of cadet flyers in the techniques of take-offs, landings, night flying, cross-country navigation, and "bailing out." Where it is impractical to "shoot" the actual subject matter, as in enemy-aircraft identification, scale models are carefully "posed" over simulated terrain, as shown in the picture at the right, and photographed.



MARKSMANSHIP training for air gunners is done by means of a lamp (right foreground at left) which throws a moving spot of light on the wall while the student, at upper left, "tracks" it with a photoelectric-cell gun mounted between the turret's two machine guns. Even when off duty, gunners practice on electric-eye guns installed in recreation rooms (below).

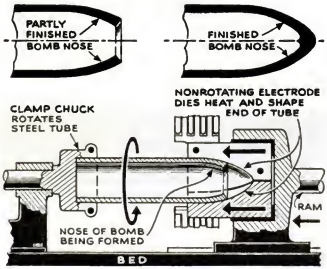


PICKABACK GLIDERS that would lend heavily loaded bombers and big transport planes additional wing surface and so help them, during the take-off, to get into the air faster, have been proposed by Vadim S. Makaroff, of New York. As soon as the big plane has reached a safe altitude, the glider detaches itself and returns to the airdrome.

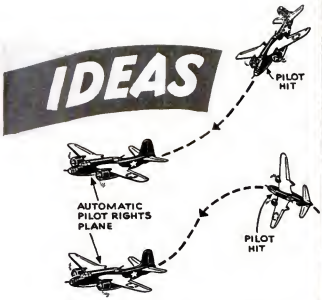


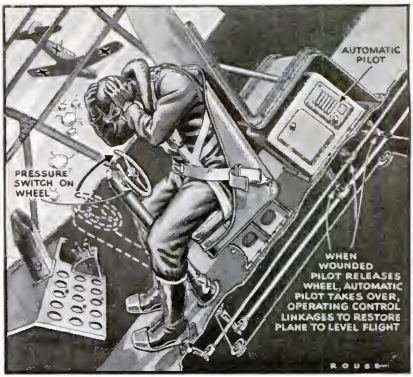
GRENADE SLINGS that would make it possible for these small bombs to be thrown much farther than when tossed directly from the hand, have been designed by R. A. Dobbelaar, of Plainfield, N. J. The sling, actually a cloth bag in which the grenade is placed, has a drawstring in the loop of which is a large wooden or plastic ball that rolls easily off the hand. This prevents the possibility of the string becoming entangled in the thrower's fingers.

SHAPING BOMB NOSES electrically is said to be improved by the apparatus diagrammed below and developed by Warren F. Heineman, of Milwaukee. A set of dies, made up of three electrodes, is forced against the partly finished nose of a bomb shell, which is made to spin in a revolving chuck. A heating current is then introduced into the bomb nose by the electrodes, and as the metal gradually softens it is formed by the pressure of the electrodes. An automatically controlled current provides graduated heating as the nose advances into the dies.



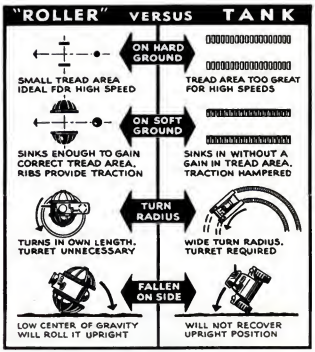
IDEAS



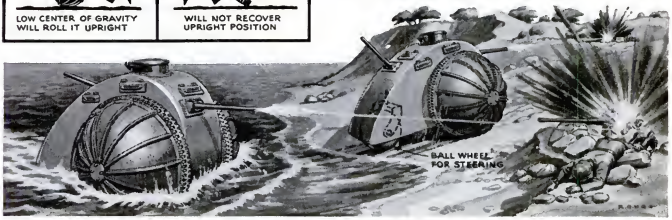


When pilot's hand leaves the stick, hydraulic servomotors actuate the flying surfaces to pull plane out of a dive or dangerous mismaneuver

AN EMERGENCY PILOT that pulls a plane back to level flight if something happens to the human pilot is saving the lives of British airmen. Unlike the ordinary automatic pilot, which is set to keep a plane flying straight and level, the new pilot automatically takes over from whatever position the plane may be in at the moment the human pilot releases the controls. In big bombers, this assumption of control gives other members of the crew enough time to take the stick if their pilot is incapacitated.



HEMISPHERICAL WHEELS are the innovation and the chief principle of the "Roller," a new amphibian combat vehicle designed by the Greek engineer Elie P. Aghnides, of New York City. Two big, ribbed, hemispherical front wheels and a spherical trailer wheel in the rear, all three empty and watertight, make the "Roller" agile on land and buoyant in water. A substitute for the tank, it will carry high-powered armor-piercing guns. Intended for combat, reconnaissance, and sea-borne invasion, it is designed to have automobile speed, to negotiate difficult terrain as well as a tank, to swivel as easily as an office chair, and to right itself automatically if upset. In mud, sand, or snow it offers greater traction surface for less penetration; in water it will both float and propel itself.



How a Violin is Made

Searching Out the Secrets of Old "Strads," American Craftsmen Now Produce the World's Finest Fiddles

TO MOST violinists, how a violin is made is something of a mystery. They know that there was once a golden age of violin making in Italy, when Stradivarius astounded the world with his instruments. And they think that age is gone forever. Actually, however, the skill and ingenuity of American craftsmen, some of them amateurs, have brought about a rebirth of the craft. We're making "Golden Strads" right here—today.

One thing that has helped is a discovery by Christopher E. Mertzanoff, of New York, an American business man and amateur violin designer, of what appears to be the secret of the proportions of Stradivarius violins. It is a geometrical equation well known to Renaissance artists and artisans and simple enough for any high-school freshman to understand. The formula is the "sectio aurea" of Leonardo da Vinci, who had died more than a century before the master violin craftsman was born. Because he found that the formula fits all the features of the Stradivarius top and back, Mertzanoff calls it, and the designs based upon it for making modern violins, "The Golden Strad."

Stradivarius and his contemporaries probably had no intention of keeping their craftsmanship a secret. Certainly they trained scores of apprentices and taught many pupils all they could. Yet somewhere the way of making these master violins was lost. For two centuries the best violin makers of Europe floundered about with futile searching after illuminating autobiographical details and unworkable formulas, and they produced only inadequate imitations. They could not equal the tonal qualities built into violins by the Italian master craftsmen.

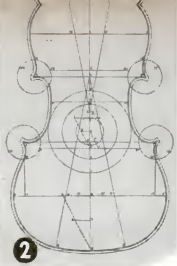
Unhampered by tradition, American designers of the past 20 years have attacked the problem in a scientific manner. Realizing that the beautiful tone of the Stradivarius results not from the aging of wood, but from some wise or fortunate combination of shape, proportion, wood grain, and even varnish, they have focused the eye of science upon each one of these in turn.

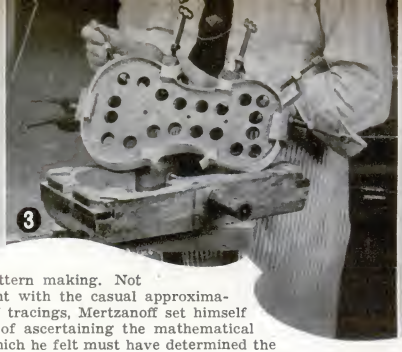
The shape of the Stradivarius had been traced and retraced in violin

A VIOLIN'S PARTS

1. Sliced maple for back
2. Sliced spruce for top
3. Neck and scroll
4. Sides or "ribs"
5. Reinforcing blocks
6. Linings for ribs
7. Decorative purfling
8. Bass bar
9. Sound post
10. Maplewood bridge
11. Strings
12. Tuning pegs
13. Top nut
14. Finger board
15. Tailpiece
16. Heavy gut
17. Tailpiece saddle
18. Tail peg
19. Chin rest

Front and rear views of a violin made from C. E. Mertzanoff's "Golden Strad" formula. The instrument is made of "Wesmeraged" wood—produced by a secret process which transforms ordinary green lumber into the equivalent of thoroughly seasoned wood





.. Underside of the top of 244-year-old Stradivarius rhown at a time of repair. Halk markings indicate ne thickness in millimeters If the plate at those points

.. This diagrammed formula If the top or back of a per-ect Stradivarius, developed y C. E. Mertzanoff, has roduced a number of ex-eptionally fine instruments

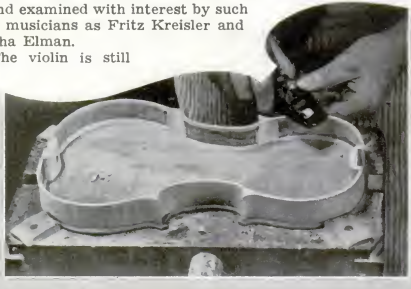
.. Violin making starts with lluing reinforcing blocks to orm, and then gluing the ix preformed ribs to the llocks. Clamps hold the ribs rmly while the glue dries

pattern making. Not content with the casual approximations of tracings, Mertzanoff set himself the task of ascertaining the mathematical formula which he felt must have determined the violins of the great Italian craftsman. His inquiry resulted in the discovery that the Da Vinci formula of the "golden section" fits exactly the proportions of the Stradivarius violin. In this formula the whole is divided into two unequal parts, with the smaller part having the same mathematical relation to the larger as the larger has to the whole.

The discovery of the Golden Strad formula is only the beginning in the vast field of violin acoustics. Mertzanoff is now making a study of dimensions and positions of the Stradivarius sound holes. He is also engaged in a scientific investigation into the acoustical properties of various woods, and with Jack Westall, of Asheville, N. C., is experimenting with a secret process for transforming green lumber into the equivalent of long-aged wood which they call "Wesmeraged" wood.

Indicative of the boom in American violincraft is the exhibition, recently held at the New York store of the Rudolph Wurlitzer Company, in which instruments valued at $100 to $800 and carved by some 92 American makers were played and examined with interest by such master musicians as Fritz Kreisler and Mischa Elman.

The violin is still



7. Back is now glued to ribs, which have been fitted with "lining" to offer more gluing surface

8. Ribs and back are removed from form, and blocks are cut to shape. Lining is made ready for top

9. Decorative purfling, to keep plates from cracking, is inserted in groove running around edge

10. Calipers are used to check thickness of plates, whose undersides have been carefully scooped out

the work of craftsmen.
The wood for its making must
be chosen with an eye that knows the grain
that will produce beauty of tone; the top and
back must be cut and scooped out with the craftsman's hand. Every part in the delicate process of making a beautifully toned violin calls for the keen eye, the trained hand, and the comprehensive mind of the expert. It calls for the personality of the artist, too—the patience, the perseverance, and the devotion of the man who works from an inner ideal. No amount of blueprinting has been able to make of the violin an assembly-line job.

Among our best American craftsmen is Carlton F. Stanley, of Newton Center, Mass., whose work is shown on these pages, and who learned his art from his uncle, F. O. Stanley, one of the inventors of the Stanley Steamer automobile. This uncle had learned the art in his boyhood from his grandfather, Liberty Stanley, born in Maine on July 4, 1776, who had taken up violin making as a hobby in his old age. Carlton Stanley's violins are played in many of our leading symphony orchestras.

American violins have not as yet attained the mellow tonal qualities of the best work of the Italian masters, but they display a sweetness and freshness of their own that surpass those of other violins of modern times and even of many of the much-sought-after older instruments. Although the amateur may still cling snobbishly to the old violin merely because it is old, the master violinist of our time, the concertmaster, and the other musicians in the string sections of our best symphony orchestras have discovered the merits of the American craftsman's violin. These men know that
old violins are not all good, that centuries of aging
will not make a good violin out of a bad one,
and that the virtue of a good violin
lies now, as ever, in design
and workmanship.

4. Outline of the ribs is now traced on flat-planed, two-piece maple billet, which is then properly trimmed. Note that the neck slot has been cut in block shown at right

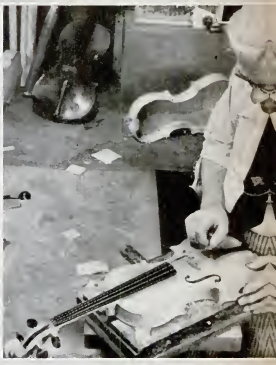
5. Rough cutting the arch of the "plate" (which may be either a violin's back or top, as both are made in the same way) is done solely by eye with a small hand plane

6. To achieve precise curvature, however, the carver must use templates. Shown here is one of a set of 13, which duplicates the curves of the Archinto Stradivarius

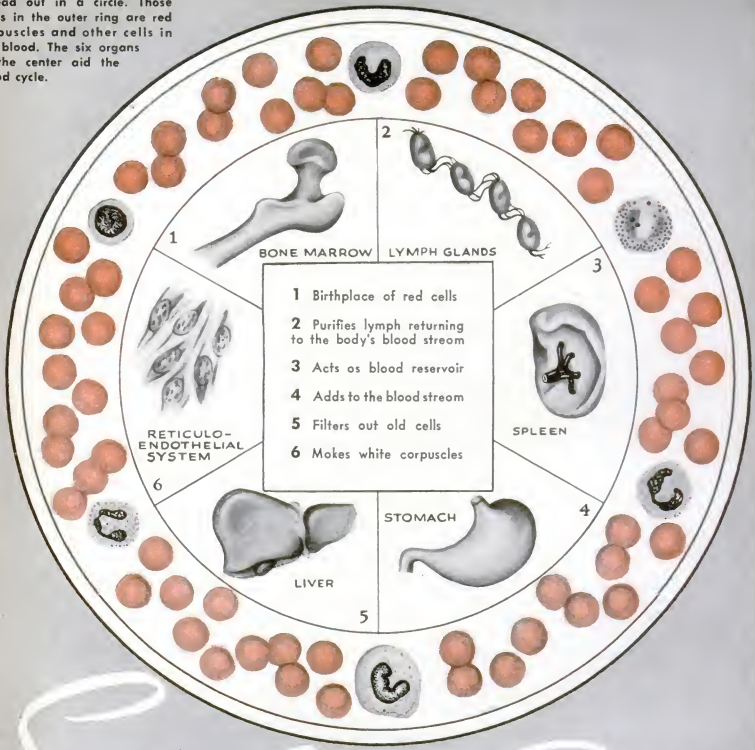
Photos by I. N. Brennan from Black Star

11. With "F" holes cut, bass bar is glued on a bit off center, and then sandpapered

12. After neck has been fitted exactly, sound post, finger board, nut, tailpiece, and pegs are put in place



13. Tuning up is an exciting moment, for no craftsman knows how a violin will sound until he puts a bow to its strings



HERE is your life stream spread out in a circle. Those disks in the outer ring are red corpuscles and other cells in the blood. The six organs in the center aid the blood cycle.

Saving Lives with Blood

The Pint You Give to the Red Cross Is Packed Full of Curative Agents for Healing the Sick and Wounded

DOCTORS once bled patients to cure them, thinking blood contained "ill humors" that made them sick. Today doctors bleed blood donors to cure others, for science has learned that human blood contains a whole warehouse of curative agents. Plasma for transfusion is only one of a dozen blood products now in use. Blood has become a major strategic weapon—to help save lives.

A donor who contributes a pint of blood is giving about one fourteenth of the amount in his system. In a person of normal health that pint is replaced within a few days, for the manufacture of blood is a basic function of the body. The red bone marrow, where the red blood cells originate, can make

By HAL BORLAND

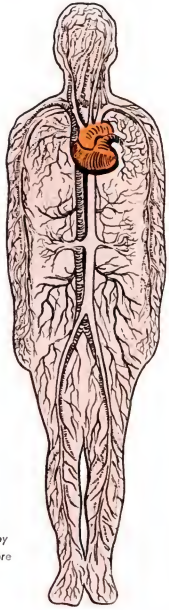
10,000,000 cells a second. The average person's blood contains trillions of these red cells; but even that astronomical quantity can be replaced in about 15 days.

Human blood consists of approximately equal portions of corpuscles, or blood cells, and plasma—the river in which the corpuscles float. Plasma is about 92 percent water. In it are dissolved salts of sodium, calcium, potassium, and phosphorus along with albumin, other proteins, and fatty substances. All are important, not only in the blood's normal function, but in the curative products science can now extract from blood itself.

Floating in the plasma are several kinds of white corpuscles, red corpuscles, and small colorless bodies called "platelets." The white corpuscles can pass through the walls of the capillaries directly into the body tissues; they are the scavengers and defenders of the body, consuming dead cells, waste products, and bacteria, and healing wounds. The red corpuscles, which cannot leave the blood vessels, carry oxygen from the lungs to the tissues. The platelets play an important part in clotting.

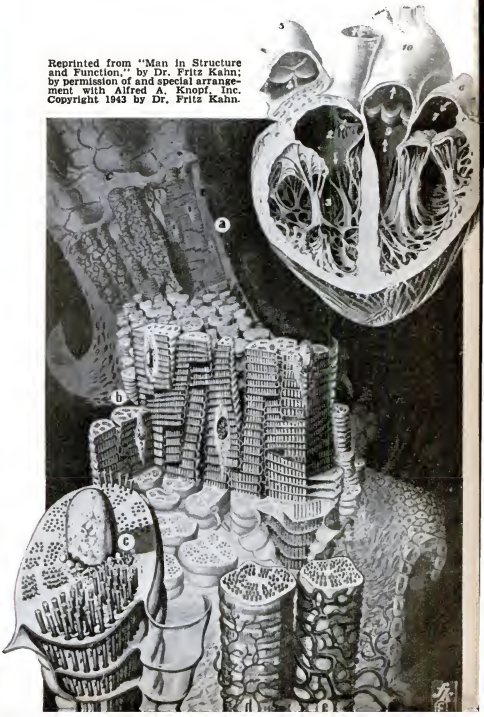
The red cells are like barges, simply making the rounds of the blood stream with their cargoes of hemoglobin, which gives them their color, absorbs oxygen in the lungs, takes it to the tissues, releases it, and is ready for another load when the red cells again pass through the lungs.

Nobody knows how red corpuscles are made in the bone marrow, but an excess of dead corpuscles seems to stimulate the production. Each corpuscle lives from 25 to 100 days and may make as many as 50,000 trips

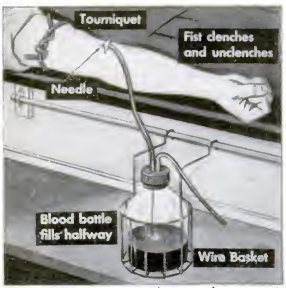


Drawings by John Gilmore

Reprinted from "Man in Structure and Function," by Dr. Fritz Kahn; by permission of and special arrangement with Alfred A. Knopf, Inc. Copyright 1943 by Dr. Fritz Kahn.



Man's blood circulatory system, shown above, is vastly complicated. Right, the human heart, from an illustration in "Man in Structure and Function," a two-volume treatise by Dr. Fritz Kahn. Blood flows through the heart in the direction of the numbers from 1 to 10. A magnified section of wall muscle is shown at *A*, a three-dimensional model at *B*, and an isolated single fiber at *C*. Special cardiac vessels *(D)* from the aorta surround even microscopic fibers with a compact network, as at *E*



Taking blood from a voluntary donor is a process lasting six to eight minutes. Each person gives a pint

Whole blood as it comes from veins

Red cells settle in centrifugation

Much is done with the blood before it can be given in a transfusion. Formerly typed according to its red cells so as not to cause clotting, it is now freed of these red corpuscles by centrifugation. Plasma is pooled, dried, and vacuum-packed. Transported then to the battlefields, it is made ready for use simply by the addition of sterile water

Plasma from number of donors is pooled, dried

through the blood stream. When it wears out, it is eliminated as the blood passes through the spleen and liver. Most of its hemoglobin is salvaged, and the liver apparently parcels it out to the bone marrow. A reserve supply of new red cells stored in the spleen is picked up by the blood when needed.

Not all red cells are alike. Those in one person may agglutinate, or gather in clots, in the serum of another's blood. So before whole blood can be transfused, it must be typed and matched with the recipient's. If contrary types are mixed, agglutination may be fatal. But when the red cells are removed, plasma can be put in any other person's blood stream without ill effects. This is a reason for preferring plasma for transfusions.

There are several types of white corpuscles. Besides ordinary leucocytes that defend the body against infection, there are lymphocytes that carry the means of making a person immune to disease. When a person has a disease, lymphocytes acquire weapons to fight a recurrence. Though relatively few in number, they are extremely potent. Science is learning more about them every day and is beginning to put them to work.

Among the soluble proteins in plasma are fibrinogen and prothrombin. In the platelets and body tissues is a substance called thrombokinase. When tissues are broken, as in a wound, both tissues and platelets release thrombokinase which, with the calcium in plasma, changes prothrombin to thrombin. The thrombin in turn changes fibrinogen to fibrin, an insoluble mass of woolly fibers in which the red corpuscles are enmeshed like fish in a seine.

If only a vein is ruptured, the clot stops the loss of blood and the white corpuscles repair the damage. If an artery is severed, however, outside help is needed, for the clot cannot hold against the direct thrust of the heart.

The heart is simply a pump, and, like all pumps, it must have something to pump or it cannot function. There are two ways in which blood pressure may fall to a dangerous level—a reduction of the volume of blood, as in a hemorrhage, and an expansion of the circulatory system making the normal volume inadequate, as in shock. In a hemorrhage, the volume must be restored to normal; in shock, the pressure must be restored. Transfusion may be required in either case.

Early transfusions employed animal blood, particularly that of sheep, and were usually fatal because the two types of blood would not mix. The next step was the use of salt solutions, with somewhat greater success. Then human blood was transfused, with far greater success after procedures were found for typing and matching. Finally came the relatively new use of blood serum, which has been highly successful. Fresh serum, shipped to England under refrigeration, saved thousands of lives during the blitz on London. Dried serum is a further devel-

opment that permits storage and shipment with a minimum of loss—it can be kept for five years, and dilution with sterile water makes it available for use anywhere.

Now an even better transfusion agent is being made from the serum itself—serum albumin. This extract is more concentrated, produces no adverse reactions, and requires a minimum of sterile water—an important factor in battle, particularly in desert or jungle. By its very nature, serum albumin prompts the body to supply the water needed to restore the blood to normal volume. The body can supply that water by drinking it, and potable water is always easier to get than water for injection.

From the serum also can be obtained fibrinogen and thrombin. By using these two substances separately, science has a new means of treating severe burns. The wound is sprayed with fibrinogen, then with thrombin. This forms a clot that normally becomes a scab and protects the area from outside infection, retains the white corpuscles that the body throws into the injured tissue, and allows the wound to drain naturally.

Another plasma derivative is gamma globulin, which apparently contains the protective antibodies that enable lymphocytes to resist recurrence of a disease. About nine of every 10 persons have had such virus diseases as mumps, measles, and influenza. When donors' blood is pooled, the antibodies are distributed, and when the gamma globulin is extracted, it seems to contain a potent concentration of those antibodies, sufficient to immunize anyone to whom it is administered. On the basis of laboratory work, such injections will enable doctors to halt an epidemic of a virus disease in its tracks.

Until recently, red corpuscles removed in the preparation of plasma were a waste product. Now, however, a means has been found to use some of them in a poultice type of treatment that hastens healing of open wounds. Fresh cells suspended in a saline solution may also be used for treating anemia. There is laboratory evidence that the red cells can eventually provide protein for peptone, a usual constituent of bacterial mediums. Pathogenic bacteria grown on such a medium may serve as an improved starting point for the production of vaccines, toxoids, and antiserums.

Both old and new uses of blood to save life have been brought to focus by the war, but work in that field is still essentially in the pioneering stage.

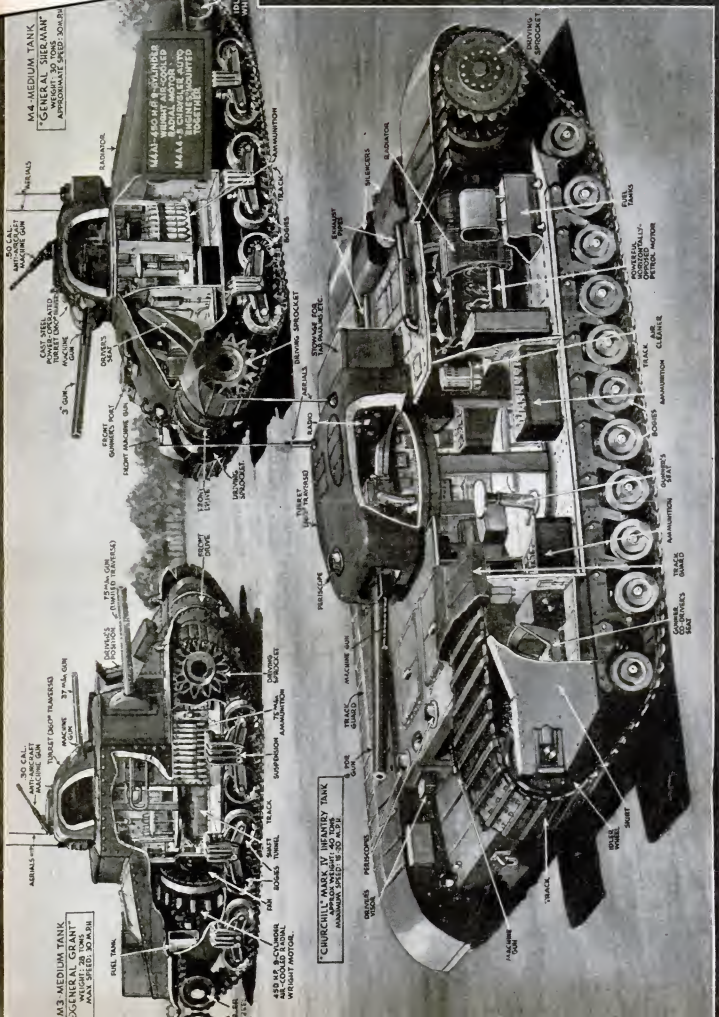
Vacuum-packed for storage or transit

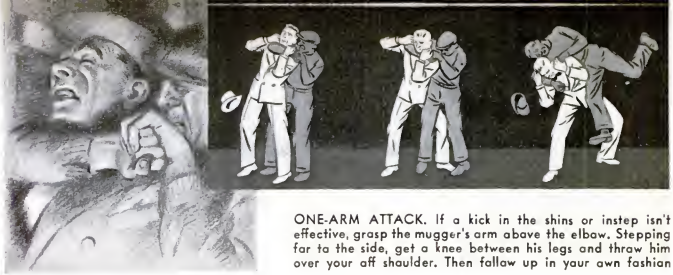
Sterile water is added, and it is ready for use

At the front, blood plasma is given to our wounded fighting men as in the photo at right, where the operation is being performed behind the lines in New Guinea. Dehydration of blood plasma, or serum, permits storage for five years or longer and also makes transportation possible, even over difficult terrain, with minimum loss. In New Guinea, Papuan natives carried the plasma to hospitals at the front

INSIDE THREE ALLIED TANKS

Internal arrangements of three leading United Nations tanks are revealed for the first time in these drawings made by G. H. Davis for *The Illustrated London News*. This trio will be right up front in the invasion of Europe.





ONE-ARM ATTACK. If a kick in the shins or instep isn't effective, grasp the mugger's arm above the elbow. Stepping far to the side, get a knee between his legs and throw him over your off shoulder. Then follow up in your own fashion

How to Beat a Mugger

MUGGING attacks, many made just for the change in the victim's pockets, are becoming more and more common. If the mugger carries a knife or gun, it is foolhardy to resist him, but there are several ways of fighting off the unarmed assailant.

A mugger launches his attack from the rear. He may throw a forearm around the victim's throat and lock it there by grasping his wrist with the other hand, or he may use both forearms and hook his hands around his upper arms. In either case, the simplest countermeasure is to give him a good, hard kick in the shins or instep. The pain may force him to let go. If this doesn't work, you'll have to try something else.

The one-arm attack usually is accompanied by a hip-line push to get you off balance. Where the mugger's right arm is around your throat, move far to the right and work your left leg behind his right. Grasping his right sleeve just above the elbow with your right hand, throw him over your right shoulder. If he is too heavy for that, get down on your right knee and roll over on him.

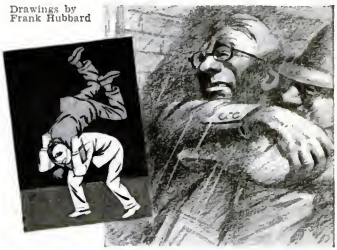
For the two-arm attack, reach up and grasp both the mugger's shoulders. Step forward with one foot, bend low to throw him off balance, and toss him over your head.

An experienced mugger may forestall such tactics by placing a knee in your back. When this happens, hook one foot behind his and push back hard. Thrown off balance, he will probably release his hold to break his fall.

What you do next is up to you. Remember, the mugger is a desperate character, so don't worry about his feelings.

In all these maneuvers, power and speed are essential. You can practice with a friend —but don't follow through, or you may cause serious injury.

Drawings by Frank Hubbard



TWO-ARM ATTACK is best countered by reaching up and grasping the assailant's shoulders. By stepping forward with one foot and bending over, you can throw him off balance and send him sprawling

If a smart mugger puts a knee in the small of your back, hook a foot behind his and push him back. He may let go to break his backward fall

Scientists Move Ahead

METEOROLOGY

A SKY THERMOMETER for measuring the temperature of the upper air has been developed by Dr. Charles M. Heck of the University of North Carolina. An improvement over a previous model (P.S.M., Dec. '38, p. 99), the current version consists of a thermometer set in the innermost of 12 concentric aluminum cones. This arrangement, Dr. Heck has found, will record the heat in the upper air uninfluenced by temperature on the ground. Since the temperature of the air varies according to the amount of moisture it contains, the sky thermometer makes it possible to determine the moisture content of the atmosphere and its tendency toward cloud formation. Possible uses for the instrument in military forecasting are foreseen.

INDUSTRY

AUTOMATIC X-RAYS of castings or assemblies are made by this new General Electric machine. Parts to be inspected are loaded on a conveyor belt and moved into place under the X-ray unit, where a pretimed exposure is made. A lead-lined shield, surrounding the unit, protects workers from the radiations.

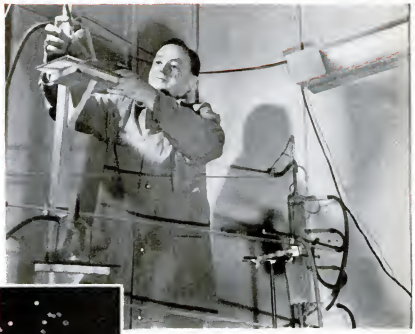
PUBLIC HEALTH

INDOOR SUNSHINE for war workers is provided by this high-powered quartz health lamp which irradiates ultraviolet rays. Accommodating 100 workers an hour, the industrial solarium builds up resistance to colds and fatigue, thereby reducing absenteeism and increasing efficiency on the job.

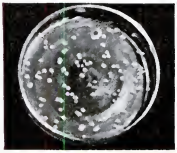
on Far-Flung Fronts

BACTERIOLOGY

LUMINOUS BACTERIA are being used by Westinghouse laboratories to test the use of the ultraviolet-ray Sterilamp in killing germs. Sprayed into the air under the lamp's rays, the harmless bacteria are caught on Petri plates, incubated, and examined in the dark, where their luminosity distinguishes them from other germs present in the air.



Dr. Harvey C. Rentschler, director of research, prepares one of the Petri plates



Far left, luminous bacteria. Left, same bacteria photographed by their own light

MEDICINE

BODY SOUNDS never before heard can now be picked up with this acoustic stethoscope developed by RCA technicians. With an adjustable range of 40 to 4,000 cycles, the instrument, besides detecting new sounds, amplifies louder ones to aid a physician in making a diagnosis.

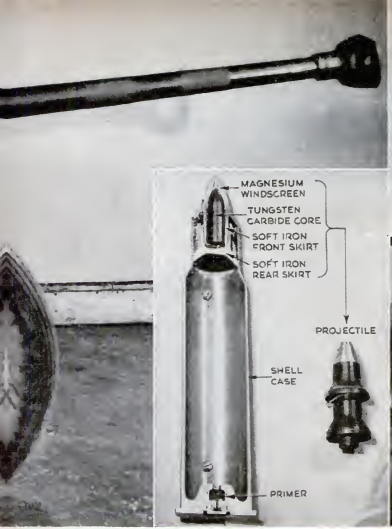
"JAPANESE LOVE KNOTS" is the name for this finger-traction apparatus which distributes evenly the pull necessary to set a fractured arm properly. Designed by Navy technicians and made of fiber or straw, the knots grasp the fingers more tightly as tension on them is increased.

Captured Guns Reveal Their Secrets

GERMAN 75-MM. GUNS mounted on eight-wheeled gun carriages capable of traveling 50 m.p.h. were used as tank destroyers during the campaign in North Africa. The gun shown at the left was captured by American troops who later turned it against the enemy

GERMAN ANTITANK RIFLE shown at left below is the standard weapon for this purpose. The 7.92-mm. (.31-in.) Model Pz. B 1939 is a single-shot gun equipped with a folding shoulder extension and a bipod that folds up under the barrel. It fires an armor-piercing tracer that carries a small pellet of tear gas to be set off by the heat of impact

JAPANESE 20-MM. ANTITANK RIFLES are fired from the shoulder off a bipod, just like most similar weapons. The one shown below at right is fed from an eight-round magazine fitted on top, and is gas-operated. The Japs have a wide range of weapons that can be used against tanks, although only one, an .80 caliber air-cooled gun, is used exclusively for this purpose



"SQUEEGEE" is the name given this German antitank gun featuring a barrel with a bore that tapers from 28 mm. at the breech to 20 mm. at the muzzle. The bullet it fires is ringed with two soft iron or copper bands that give it the 28-mm. diameter as it is exploded from the shell. But as it travels through the bore, the rings are compressed to the smaller dimension at the muzzle, where they drop off. Purpose of this construction is to afford a larger area to build up pressure against in a chamber made gastight by the metal skirts. Below, a soldier at Aberdeen demonstrates the use of the telescopic sight

THE ENEMY HOPED TO STOP US WITH THESE WEAPONS, NOW BEING EXAMINED BY ARMY EXPERTS AT THE ABERDEEN PROVING GROUND

GERMAN 88-MM. GUNS, like the one shown at the right, were built for use against aircraft, but during the drive against the Maginot Line it was found that their high muzzle velocity would pierce armor, and this led to their use as antitank guns in Africa. Maximum horizontal range of the 88 is 18,000 yards; effective ceiling (at a 70° elevation) is 25,000 feet. Handled by a crew of six, it can be set up in 3½ minutes. Comparable U. S. weapon is the dual-purpose 90-mm. gun, which fires a heavier projectile farther

ITALIAN ANTITANK GUN. The 20-mm. Solothurn, shown below at right, is a self-loading weapon using the recoil system of operation that fires at the rate of 10-20 rounds a minute. The sights include a blade front sight and a leaf back sight graduated to 1,500 meters, in addition to a telescopic sight mounted on a bracket. Copied after a Swiss gun, the Solothurn is fed by a clip magazine capable of holding 10 rounds, but usually loaded with eight. Overall length, including the recoil reducer, is just over seven feet

WAR HOOKS THE

Photos by HAROLD W. KULICK

Now that his liver is worth nearly $10 a pound, there's a price on his head and fishermen are going after him in earnest.

SHARK fishing is enjoying a boom. After the German occupation of Norway cut off our main source of cod-liver oil, researchers discovered that oil from the liver of the shark had an even higher vitamin content, with the added advantage of being odorless and tasteless. It is being given to pilots to aid night vision. The oil also has uses in the manufacture of cosmetics and as a cooking fat.

While the liver is the greatest prize, in some cases worth nearly $10 a pound, other parts of the shark have commercial value. The skin goes into shoes and handbags, the teeth and vertebrae into jewelry. Physicians use

A precious trophy: a shark's liver. Average liver weighs about 80 pounds and yields around 50 pounds of the precious vitamin-packed oil

From shark's liver to pilot's eye . . . Preparing oil for vitamin

Ashore, sharks are cut open from the top to prevent damage to the soft belly hide, most valuable part of the skin

To extract oil, the liver is chopped up in a meat grinder and then boiled in large vats. When the liquid has reached a thick consistency, a centrifugal separator removes all foreign matter

SHARK

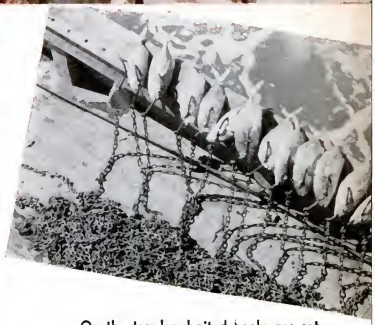
serums extracted from the shark's pituitary gland. Chinese restaurants make soup from the fins. The flesh is canned for food, and the rest of the shark goes into fertilizer.

To cash in on this bonanza, shark fishermen have abandoned the slow and dangerous hand-and-line technique. Trawlers drop 1,000-foot chains which are anchored at both ends and marked by buoys. At 25-foot intervals on the line are six-foot chains with large hooks. After a day or more, the trawlers locate the buoys and draw in the lines with special chain winches. From six to 10 sharks may be found on each 1,000-foot line. Most of them are already drowned, but an occasional tiger shark will come aboard with plenty of fight in him and will have to be quieted with a crowbar.

Hauling in a catch. Sharks hooked on chain lines are gaffed and hoisted aboard. Most are already drowned

that gives flyers night vision

Fresh from the centrifuge, refined shark-liver oil is poured off into drums for shipment to pharmaceutical houses. A 50-gallon drum may be worth up to $7,000



On the trawler, baited hooks are set in holes in the gunwale to make it easy to pay out the 1,000-foot chain line without tangling. Bait is mullet or kingfish, favorite food of sharks. Hooks are on six-foot chains which are attached to the main chain line at 25-foot intervals. An average haul will net six to 10 sharks to the line

What's Your Score on Identifying

WOMEN'S WAR BONNETS?

CAN you tell an enlisted WAVE from a SPAR ensign? The service hat is your sure guide. Here are the distinctive headgears of 10 military or volunteer services. If you've been watching war styles, you should be able to identify the wearer's rank as well as service corps. Check answers below. Seven right is a good score.

1. Army Nurse
2. WAFS—pilot
3. Amer. Women's Vol. Ser.
4. Marines—officer
5. Red Cross Spec. Ser.
6. Navy Nurse
7. SPAR—officer
8. WAAC—officer
9. Air-raid warden
10. WAVES—officer

Horse Meat Is Favorite Dish of Circus "Cats"

DON'T worry about what Leo the lion is having for dinner tonight—or lunch tomorrow. Meatless Tuesday and Ration Book Two mean little to the Big Top, for, provided there's a horse market near by, circus animals will dine well without benefit of OPA. Time-honored fare of a circus tiger, puma, leopard, or bear is about 15 pounds of juicy horse meat a day, for which no red stamps are needed. Gorillas, amiably enough, are as strict as G. B. Shaw in abstaining from meat of any kind, while elephants get those strong, white tusks from buckets of bran. Camels thrive on a gourmet's dish of cod-liver oil in milk. Main headache of the Big Top in feeding its diversified charges under wartime conditions is in procuring hay. The Army wants it, too.

That quartette of expectant looks (top) is there simply becouse the doily flank of Dobbin hosn't been served up yet. Luckily, most circus onimols prefer horseflesh to beef, so that tentmosters don't hove to worry obout red rotion stamps. Those opprehensive brethren on the lodder ore cannily computing the distonce to the sawdust, os this act in Ringling Brothers' Circus reaches o cruciol moment. "No more cod-liver oil—I feel fine," roors the tiger ot left os he sees his keeper coming to doctor him

No Truce in the War

Fighting flames with an OCD hand pump. This new extinguisher was developed in collaboration with the

Shortages of rubber and brass threatened safety Laboratories found ways to guard priceless military

By HICKMAN POWELL

ONE of the first results of Pearl Harbor was a sudden, vast increase in demand for fire-fighting equipment. Municipalities that had economized on fire hose during the depression immediately poured in orders for new supplies by the millions of feet, while the Army, the Office of Civilian Defense, and war plants added their weight to the demand. Meanwhile householders, acutely conscious of incendiary bombs, wanted fire extinguishers. The OCD with its air-raid precautions whipped up the natural demand to an even higher pitch. But at the same time the War Production Board started clamping down on rubber, brass, and other necessary materials.

All this created something of a crisis in the big Chicago testing station of Underwriters' Laboratories, Inc., which had spent nearly 50 years in building up rigid specifications and standards in all matters related to the prevention and fighting of fire. Underwriters' Laboratories was established under the auspices of fire-insurance companies to provide manufacturers with thorough testing which would give their goods a certified safety factor. But now something more urgent than insurance losses or ordinary safety was at stake. Failure to adjust requirements promptly might have led to a breakdown of fire safety standards at a time when it would have been disastrous, since war supplies are priceless and most civilian equipment is irreplaceable.

Hose is now being produced with malleable iron instead of brass couplings, and

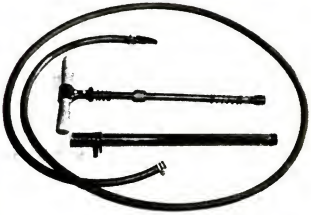
on Fire

Underwriters' Laboratories and fire-equipment makers

Plastics are used for pump valves, nozzles, and pistan parts, and glass marbles for the valve balls, to save an critical materials

At right, a complete OCD hand pump. The tank is galvanized

Pump tubes are made af enameled steel instead of brass. The hase is made entirely af reclaimed rubber



standards, but Underwriters' and home-front supplies

it is just as strong as prewar hose, though only seven pounds of crude rubber are allowed where 17 were used before. The dilemma was met by changing the time factor. Standard fire hose is made of a 2½-inch cotton casing, lined with a thin soft-rubber tube that must stretch both in diameter and length. It was found possible to provide this with reclaimed rubber by sacrificing something in length of life. Today's hose is good enough to last at full efficiency probably to the end of the war, certainly until after synthetic rubber is being produced in volume. One length out of every 200 is tested exhaustively to make sure. The aging factor is determined by placing a sample in a bomb of pure oxygen and bathing it in hot water for several hours to speed the process of oxidation. For fire hose must work, not only now, but for as long as it continues to be in use.

In peacetime, Underwriters' big laboratories are a passing show of new industrial products being put through the most difficult situations imaginable. There are, for instance, long rows of furnaces where oil burners used to go through exhaustive tests; these are cold now. The men who used to test juke boxes, to see that customers would not be knocked over by electric shock, get their chance instead at soft-drink dispensers that are being made for the Army. But for the most part the job is to determine the efficiency of substitutes and of new materials being developed for use in war plants.

One urgent problem was to find a hand fire extinguisher which would not draw on precious supplies of copper and brass. The OCD wanted them by the millions, and is now getting them. In collaboration with manufacturers, the laboratories worked out an extinguisher that will hold four gallons of water and is made almost entirely of

TESTING ELECTRICAL INSULATION

While 100,000 volts are applied, a sheet of insulating material is tested, at left, to determine its protective value. The setup at Underwriters' Laboratories is used to try out insulations for all types of electrical devices

noncritical materials. Its operation is similar to that of the five-gallon pump tank with which fire departments put out a majority of the blazes to which they are called. The pump, instead of being made of critical brass, is steel and kitchenware porcelain, while the valve ball is a glass marble. With a reclaimed-rubber hose and a plastic nozzle, the extinguisher is adequate for most small fires.

Other substitutes of major importance are the new insulations for electric wire, replacing rubber. The war has given great stimulus to the production of wire with synthetic plastic insulation, known as SN wire. The material used is a plasticized polyvinyl chloride, a thermoplastic similar to Vinylite and Koroseal. Pliable unless chilled, this new type of wire is especially useful in airplanes and on other complicated jobs, for the material can be produced in a great variety of contrasting colors.

Also used today in large quantities for war construction is paper-insulated emergency-installation wire, which serves very well and safely as long as it is kept dry. One type of EI wire has the metal wrapped in two strips of cellulose acetate butyrate, which is also used for 16-mm. safety film. A .003-inch thickness of this stuff will resist 1,500 volts. Around this are twisted eight strips of paper and a cotton wrapping impregnated with a flame-resisting and moisture-retarding substance.

Another form of EI wire is simply wrapped in interwoven strips of paper, saturated with pitch. These emergency-installation wires may not be used in the usual metallic cables, where water might condense. Nonmetallic-sheath cable is permitted, but it must be installed where it can be seen, so that it will be replaced after the war.

While many ordinary industrial articles have gone out of circulation, there has been a boom in the testing of articles related to explosions. Incidentally, the Laboratories have discovered, at their explosive proving grounds outside Chicago, that it does no good as bomb protection to paste strips of

MALLEABLE-BRASS HOSE COUPLINGS GET SEVERE TRYOUTS

In a salt-spray chamber, above, a new coupling is tested for corrosion; at left, the coupling stays on a length of fire hose under high water pressure

Above, an expander is used to fasten a malleable-iron coupling on a piece of hose. An old-type brass coupling is on the other end. The only brass in the new coupling is in the swivel ring

tape on window glass—no good, that is, unless the strips are also made fast to the sash which holds the glass. Wired glass is almost three times as resistant to an explosion's suction as plain glass.

Underwriters' Laboratories helped the Army work out lightning protection for ammunition dumps by welding together the steel framework of the reinforced-concrete "igloos" in which the ammunition is stored, and putting points at the top. In this way tremendous quantities of strategic copper were saved.

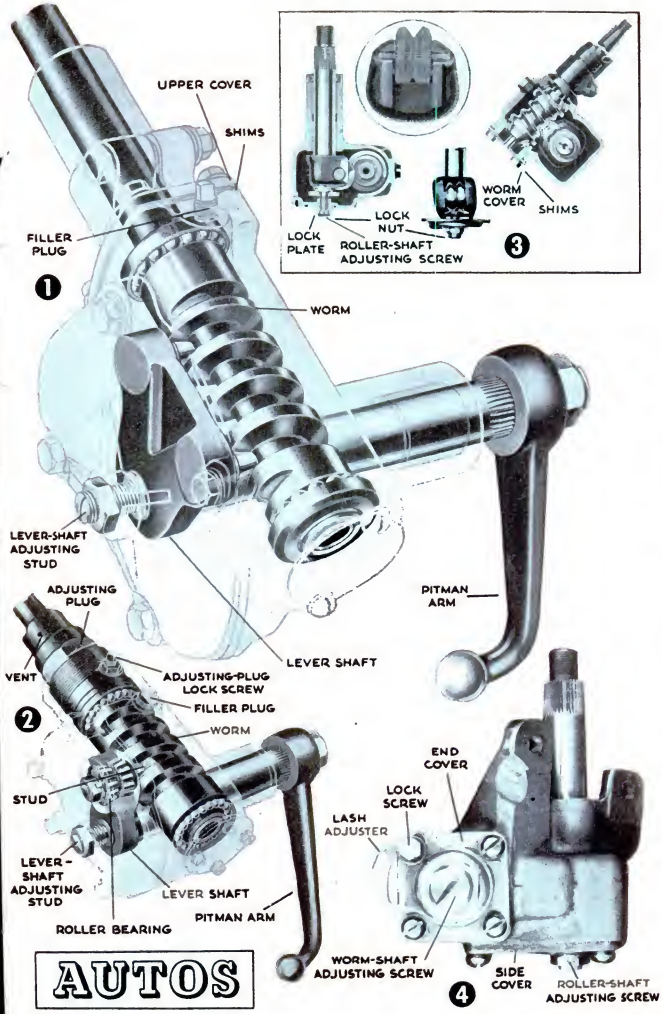
Conductive shoes, required in hospitals and munit plants to eliminate a static-electricity hazard, rec a thorough test for both wear and loss of conduct

SWITCH CASES MUST WITHSTAND BLASTS

Wide, matched flanges and a heavy case confine explosions started by sparks. A gas-filled switch case is tested below in a box also containing an explosive vapor

Plates on the inner and outer soles of conductive shoes prevent the building up of static electricity in the body by allowing it to escape to the ground

Overshoes of conductive rubber are furnished to visitors at some plants. They are connected to the bare leg since wool and silk socks are insulators


UPPER COVER
SHIMS
FILLER PLUG
1
WORM
LEVER-SHAFT ADJUSTING STUD
PITMAN ARM
LEVER SHAFT
ADJUSTING PLUG
VENT
ADJUSTING-PLUG LOCK SCREW
FILLER PLUG
2
WORM
STUD
LEVER-SHAFT ADJUSTING STUD
LEVER SHAFT
PITMAN ARM
ROLLER BEARING
LOCK PLATE
LOCK NUT
ROLLER-SHAFT ADJUSTING SCREW
WORM COVER
SHIMS
3
END COVER
LOCK SCREW
LASH ADJUSTER
WORM-SHAFT ADJUSTING SCREW
SIDE COVER
ROLLER-SHAFT ADJUSTING SCREW
4

AUTOS

TAKING THE KINKS OUT OF *Steering Systems*

1 Ross twin-lever gear. To eliminate end play in the worm, loosen the lever-shaft adjusting stud, releasing the pins in the thread, move the upper cover out, and add or remove shims between the gaskets as required; then push the cover back and tighten. In adjusting the mesh of the worm thread and pins, center the steering wheel in the straight-ahead position, tighten the lever-shaft adjusting stud until a slight drag is felt in the middle of the turn as the wheel is rotated slowly from one extreme to the other, tighten the lock nut on the stud, and give the gear a final test

2 Ross roller-bearing mounted-stud gear. To eliminate worm end play, free the stud from the thread by loosening the lever-shaft adjusting stud; then back off the adjusting-plug lock screw and turn down the plug until the drag is barely perceptible when the steering wheel responds to a light grip of the thumb and forefinger. Tighten the lock screw and its lock nut. Backlash in the lever-shaft stud is eliminated in the same way that the worm and pins of a twin-lever gear are meshed (see above). To adjust the roller-bearing stud unit, straighten the bent prong on the lock washer, hold the stud to keep it from turning, and tighten the nut until taps on each end of the stud show the adjustment to be correct; then bend up a locking prong that has not been used before

3 Gemmer external mesh-adjustment gear. To do away with up-and-down motion in the steering column, loosen the worm-cover screws slightly and remove the top shim, separating it from the next with a knife blade run in carefully so as not to mar those remaining; then tighten the cover and test the column. Repeat, if necessary, removing one shim at a time until play is corrected, but if the gear should then bind at any point, one of the shims will have to be replaced. To eliminate end play in the roller shaft, turn the steering wheel to either extreme position and back it one eighth of a turn, loosen the lock nut, and turn the adjusting screw until there is no more end play present; then tighten the lock nut and check for end play and binding through the entire range of the gear. In adjusting the mesh of the worm and roller, remove the roller-shaft lock nut and slip the lock plate down to clear the boss on the cover; then, with the steering wheel centered and the drag link disconnected, tighten the adjusting screw on the roller shaft just enough to get rid of play between the worm and roller-shaft teeth. Check by pulling the pitman arm back and forth. When the adjustment is satisfactory, slide the lock plate back into position, and replace and tighten the lock nut. A cross-sectional view of the roller bearing is shown in the circled inset

4 Saginaw worm-and-roller gear. This external view shows worm and roller-shaft adjusting screws and lash adjuster, all reached from the outside. Detailed instructions and an exploded view of the gear are given on the following page

By RALPH ROGERS

MANY a fender has been crumpled because of too much play in the steering wheel. Quick-witted though a driver may be, he cannot avoid a crash if it occurs in the fraction of a second required to overcome lost motion before his steering gear begins to function.

What is probably the best insurance is to keep the steering system properly adjusted at all times. This can be done easily by anyone who understands certain fundamentals about steering gears and has a few tools.

Before making any adjustments in the steering gear, however, jack up the front wheels and make sure that the excess play is not caused by some other part of the car mechanism. For example, do not attempt to make adjustments in the steering gear to correct any erratic action of the front wheels evidenced by wheel shimmy or wandering to one or both sides of the road.

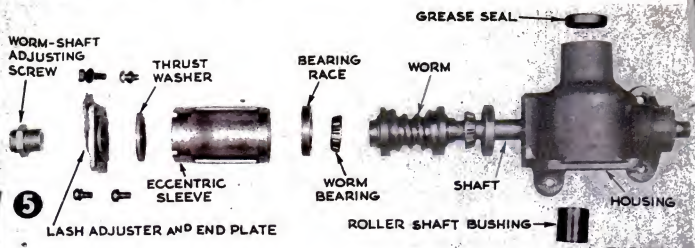
If one of these should be your trouble, check the tires for proper inflation and have the wheel alignment looked over by an expert who has the equipment to do a scientific job. Shock absorbers should also be in good working order. Shimmy can sometimes be caused by nothing more than the use of a boot in a front-wheel tire.

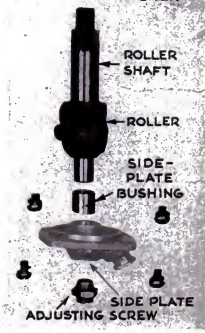
If all of these parts measure up satisfactorily, then check on the steering gear. The tie-rod and drag-link sockets and connections should operate freely without end play. Make certain that the pitman arm is tight on the steering-gear cross shaft and that its lock washer and nut also are tight.

The steering gears illustrated are typical of those in use in the majority of cars for the past several years. Compare the gear in your car with those in the illustrations; then choose the one that looks like yours and study its design carefully. This will enable you to proceed intelligently with adjustments and, if necessary, a job of overhauling.

End play in the worm (or cam) shows up as play in the steering tube, indicated by up and down movement of the steering wheel. This adjustment is correct if the steering wheel responds freely when lightly gripped by the thumb and forefinger. Should end play be barely perceptible, no adjustment is necessary.

Misalignment of the steering column is





In eliminating end play in the worm shaft of a Saginaw gear (shown here in an exploded view), loosen the adjusting screw until there is a slight load on the steering wheel when the gear reaches its extreme position. Take care not to back the screw out far enough to let the worm bearings get out of line. To adjust the roller shaft, tighten the four screws holding the side cover, loosen the lock nut, turn the adjusting screw all the way down, back it off slightly, and retighten the lock nut; then turn the gear almost to each extreme and check for binding by moving the pitman arm back and forth. Backlash between the worm and roller may be determined by tightening the screws in the end cover, centering the steering gear, and moving the pitman arm back and forth. To correct it, loosen the lash-adjuster lock screw and, with a soft hammer, tap the adjuster 1/16" at a time in the direction of the cutout arrow until the adjustment seems satisfactory; then turn the steering wheel to the right and left to check for tight spots, eliminating any that show up by tapping the adjuster back slightly so the gear will turn without excessive binding; then retighten the lock screw

corrected by loosening the bolts that hold the gear to the frame just enough to allow the gear to shift and to line up as much as it will of its own accord at the angle determined by the setting of the steering-column bracket at the instrument board; when the gear is in this normal position, it is again tightened to the frame. After this has been done, loosen the instrument-board bracket and allow it to shift so that its position and that of the steering column are matched perfectly, and then tighten the bracket. If the bracket is of the single-position type, it must be changed to the position of the steering column. Never try to spring the column to the bracket—this is just the condition that you are trying to correct.

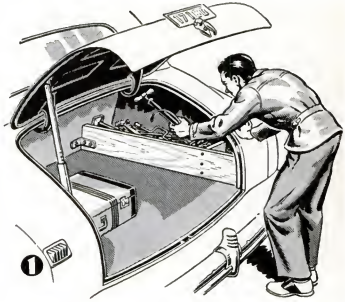
To locate the steering gear in its central position, turn the steering wheel from one extreme to the other, keeping count of the number of turns. Next, turn the wheel back precisely one half the total number of turns, and this will be the central position of the gear. Most wheels have a trade-mark or depression on the underside of the spoke that should point directly up or down when the gear is in this central position.

Specific directions for the adjustment of the several types of gears pictured are given along with the illustrations. Select the set that fits the steering gear in your car and follow the steps in the order listed, first, however, disconnecting the drag link from the ball end of the pitman arm in order to free the gear of load. When the adjustment is made, the gear should be free from backlash in its straight-ahead driving position and should be free to move through its complete cycle without binding at any point.

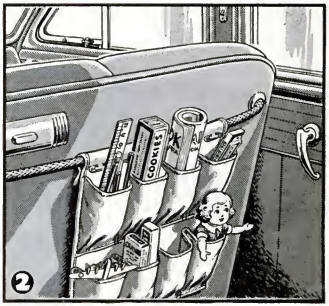
Before reconnecting the drag link to the pitman arm, turn the steering wheel to its central point and place the front wheels in their straight-ahead position. It should then be possible to connect the drag link without moving the steering gear appreciably. If this cannot be done, remove the pitman arm from the steering-gear cross shaft and place it on the splines in the correct position, otherwise the front wheels will not swing through equal arcs to the right and left.

USEFUL AUTO HINTS

1 **A TOOL COMPARTMENT** for cars lacking such a space can be made by welding or bolting an angle bracket in the luggage compartment to the bottom of the back of the rear seat. A board is fitted between the seat and the end of the body and is bolted to the bracket. A cross board keeps tools from damaging the taillight.—P.C.S.



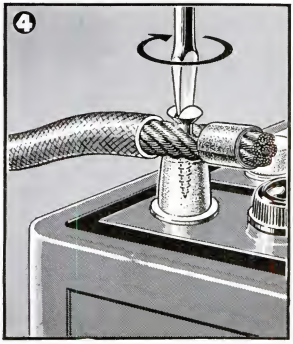
2 **AN ORDINARY SHOE BAG** temporarily fastened to the rear of the front seat with safety pins provides a handy place for carrying articles with which to entertain small children during an auto trip. The pockets are suitable for small toys, dolls, paper and pencils, flexible books that can be rolled, and boxes of cookies.—C.W.C.

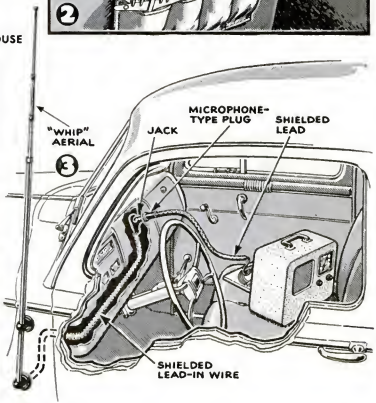


3 **PORTABLE-RADIO RECEPTION** in an automobile may be improved with a few simple connections. Use a standard whip aerial, connecting it with a shielded lead-in to the plug jack on the dash. A 3′ piece of single-conductor shielded cable is attached to a microphone plug, with the shield connected to the shank, and fastened at one end to the grid side of the loop aerial. The shield may be fastened to the radio chassis if this will further improve reception. Be sure to keep all the shielding grounded to eliminate ignition noises.—R.S.

4 **EMERGENCY BATTERY CONNECTIONS** can be made by taping the cable end and turning an ordinary wood screw through the cable into the battery terminal.—J.K.

DRAWINGS BY STEWART ROUSE





Gus Meets

REPAIRS CAN BE COSTLY IN MORE

By MARTIN BUNN

JOE KENT, a Model Garage old-timer who now lives in New Jersey, snapped his fingers impatiently.

"I can't understand it!" he exclaimed. "When my repair man over home said that this fuel pump had gone haywire, I wouldn't believe him. That's why I took a chance on getting stalled on the road to get my car over here to you, Gus. This is the third fuel pump that's gone bad on me this year. And I've driven only six thousand miles. Why, I used to drive three times that much before the war, and I can't remember ever having fuel-pump trouble. What's the answer?"

Gus Wilson looked up from the fuel pump he had taken off Kent's car and disassembled on his workbench. "I don't know all the answer yet, Joe," he said. "But I do know that your pump won't work right because some of its parts are corroded. Right now there's moisture on them. Feel for yourself —right here."

Kent ran a finger over the place Gus indicated. "It's wet, all right," he agreed. "But where the heck did the water come from?"

"I've checked on that," Gus told him. "The crankcase is the only place it could have come from."

"Huh?" Joe retorted doubtfully. "Be yourself, Gus. How could water get into the crankcase and then out of the crankcase onto the fuel pump?"

"It wasn't water when it came out of the crankcase," Gus said. "It was moisture in the form of vapor, and it condensed into water. . . . Know anything about crankcase ventilation, Joe?"

"Sure I do!" Joe asserted. "It's—it's—Oh, you know—it sort of ventilates the—"

Gus laughed. "Stop stalling," he said. "Crankcase ventilation is just a couple of words to you, same as it is to ninety-nine car owners out of a hundred. It's one of the most important features of modern engine design, but somehow most owners can't appreciate its importance. There are several systems, but they all have the same object—to force gas vapors out of the crankcase before they have a chance to condense and dilute the engine oil and do other damage. I'm going to do some checking on your car. If you watch, you'll find out why those three fuel pumps went bad after only a couple of thousand miles."

Gus examined the air cleaner on the carburetor of Kent's car and found it in A-1 condition. Then he examined the filter in the crankcase oil-filler cap. It was hopelessly clogged—and to make it even worse, someone had installed the cap with its opening faced toward the back end of the car instead of toward the front end.

"That filter is the cause of all your grief," he told Kent. "When it's clogged up, no air can get through the oil filler pipe. That means that the only ventilation the engine gets is through the outlet pipe. And, of course, putting that cap on wrong-side-to didn't help any. These filters must be kept clean so they'll let the air flow freely through the crankcase and carry off the vapors. That keeps the oil from becoming diluted.

"Keeping them clean is especially important now," Gus went on thoughtfully, "because people don't use their cars so often since gas rationing, and only take short trips when they do. Consequence is, the engine seldom has a chance to get warmed up thoroughly and pass off the vapors in the exhaust. Few owners understand this wartime handicap, and a lot of them are having troubles like yours. And it's a real headache to the service garages. . . . Well, I'll have to clean out that clogged filter. Then I'll install a rebuilt fuel pump for you."

"O. K., Gus," Kent said. "And when I get back home I'm going to give that repair man of mine a good lecture on crankcase ventilation!"

"You do that, Joe," Gus laughed. "Now that you know what it's all about yourself."

Not long after Kent had gone on his way, Vernon Hopkins drove his car into the shop. Most folks in our town think that Vern is a hopeless sourball, but Gus always stands up for him.

"Give me a chance to check a man's car," he says when someone starts panning Vern, "and I'll tell you all you need to know about his character. Vern may be a grouch, but anyone who keeps a five-year-old bus run-

Double Trouble

WAYS THAN ONE—ESPECIALLY IF THEY ARE BUNGLED

ning as smoothly as his, certainly must have some good in him. There's nothing really wrong with Vern Hopkins. His car proves it."

Feeling that way, Gus greeted Hopkins with a friendly, "Hello, there."

Vern had a scowl on his thin face, and he didn't bother to wipe it off when he returned Gus's cheery greeting with a grunt.

"I want you to look at my motor," he grumbled. "Every once in a while it skips three cylinders, and I can't find out why. It's got me worried." He got out, leaving the engine running. "It's doing it now. Hear that?"

Gus nodded. His trained ear told him that there were only three cylinders firing. Knowing how careful and smart Vern is about car upkeep, he felt that he probably had a tough trouble-shooting job ahead of him.

Hopkins hunched his bony frame on the end of the workbench and watched silently and with a scowl as Gus began checking.

While the engine turned over slowly, hitting on only half of its six cylinders, the proprietor of the Model Garage detached a wire from a spark plug and held its end a quarter of an inch from the plug shell. He got a good spark. The next two plugs he tested also gave good sparks. As he reconnected the wire to the third plug he looked surprised. All the cylinders were firing now. But just to be on the safe side, he checked the three remaining plugs. Like the three checked first, they all gave good sparks.

He grinned at Vern. "As soon as a good man goes to work on your engine," he said, "the trouble vanishes. It's hitting on all six now."

"I can hear that," snapped Vern. "That's the way it's been acting for several days. Sometimes it runs all right, and sometimes it don't. Why?" he demanded, pointing his long thin finger at Gus. "That's what I want to know—why?"

Gus picked up his pipe from the workbench and felt in his overalls pocket for his tin of "Delight"; then remembered that he had left it in the office. He went to get it. When he came back a half minute later, Vern jerked a thumb at his car. "What'd I

Hopkins sat on the workbench as Gus checked. "You're stumped," he jeered

tell you?" he growled. "It's missing again."

"So it is," Gus agreed placidly. "Well, that'll make it a lot easier to locate the trouble."

After switching off the engine, Gus made a quick but careful check that failed to reveal any loose connections. A test of the battery disclosed that it was putting out an adequate amount of current. No cracks showed in the distributor cap. When he pulled the spark-plug cables out of the cap sockets, he found both the terminals and the sockets clean and uncorroded.

Gus's pipe had gone out. As he relighted it, he did a little hard thinking. Vern's tight lips twisted into a sneer. "You're stumped," he gloated.

Gus grinned at him. "Close to it, but not quite," he said. "Any number of things can make an engine miss that haven't got anything to do with the ignition. Carburetor trouble, for example."

But when he checked the carburetor, he found that it was delivering a satisfactory mixture to the cylinders. His tester told him that the compression of each of the cylinders was good. He could find no leaks in the manifold.

"That puts me right back where I started from," he admitted. "It must be ignition-circuit trouble. Can't be anything else. I'll take a look at the coil."

"You needn't," Vern told him. "I put in a new coil as soon as she began to miss, and it didn't do a bit of good." He was looking almost happy. "Now you *are* stumped!" he jeered.

Gus almost lost his temper, but not quite. "The jinx must be in your distributor," he said. "Let's have a look at it."

"Huh?" Vern grunted. He got red in the face. "There's nothing the matter with that. Why, I—oh, well, go ahead and look at it."

Gus took off the distributor cap. The rotor was in good condition. He lifted it off and looked at the points. "You been doing any monkeying with this?" he demanded of Vern. "These points look new, and so does the breaker lever."

"They're new," Vern admitted. "What of it?"

"If you'd told me that half an hour ago you'd have saved me a lot of time—and what it'll cost you to pay for that time," Gus told him disgustedly. "You certainly made a bum job of installing that breaker lever. Here. See that grit? That's what's been making your engine miss."

"Grit? Well, all right. So there is a little grit," Vern Hopkins mumbled grudgingly. "But that little bit wouldn't make the whole engine miss," he asserted belligerently.

"Oh, wouldn't it?" Gus retorted. "The bushing on that breaker lever fits tight enough as it is—because it's new. Now you try to wedge it to the pivot post even tighter by getting dirt between them. How do you suppose it can move to make the contact to close the primary circuit? Sure, it'll work sometimes, but when it doesn't, there's no current going to the ignition coil and no spark in the cylinder. Result is, the cylinder misses fire. Catch on?" Gus grinned mischievously.

"No," Vern returned flatly. "Besides I don't believe it anyway."

Gus laughed out loud.

"Well," he said, "maybe you'll believe me when you see your headaches go away with this grit."

He cleaned the grit from the lever bushing and from the pivot post. Then he replaced the distributor cap.

"Try it now," he invited.

Vern got into the car, stepped on the starter, and the motor purred without even the slightest hint of a miss.

"Send me a bill," he grumbled ungraciously. "And see that you don't charge me too much."

"Don't worry about that," replied Gus. "I'll even throw in a bit of free advice. Next time you work on your car, don't be so sloppy. Why, I'd fire a mechanic for being half that careless—even though mechanics are hard to get."

He ambled over to his workbench and picked up a hammer.

"Some people will just never learn . . ." he muttered, but the rest of his words were drowned in the roar of the exhaust from Vern's departing car.

"If you're going to be your own mechanic, be a good one," Gus mused. "Or a clean one, at any rate." Then he chuckled. "At that, I guess Vern Hopkins wasn't as bad as Joe Kent's mechanic over in Jersey. At least he didn't damage someone else's property."

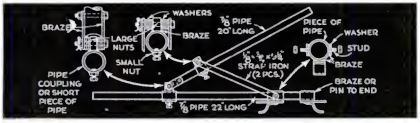
$175 IN PRIZES

ATTENTION, auto, truck, and jeep experts! For the best letter of not more than 500 words describing a car ailment, its diagnosis, and cure, we will pay $50. The second-best will win $25, the next five best $10 each, and the next ten best $5 each. In case of a tie, each tying contestant will be awarded the prize tied for. The editor's decision will be final.

Address letters to Gus Wilson, care of POPULAR SCIENCE MONTHLY, 353 Fourth Avenue, New York 10, N. Y. Letters must be postmarked before midnight, September 15, 1943. No entries will be returned, and all will become the property of POPULAR SCIENCE MONTHLY.

EMERGENCY AMBULANCE BODIES have been designed by the OCD for use on converted light four-door sedans as supplemental equipment for its medical division. The bodies, which accommodate four stretchers, are built of wooden frame members and plywood panels. Scrap iron is used for lengthening the chassis of the converted cars. In making the ambulances, the sedan bodies are cut off at the rear of the center door posts, the new bodies are bolted to bent iron pieces welded to the chassis, and two additional leaves taken from junked cars are inserted to strengthen each rear spring. The bodies may be used on 1939, 1940, and 1941 Fords, Chevrolets, and Plymouths. That in the photo above is mounted on a 1939 Ford.

TIRE INSPECTION can be speeded in a busy shop by the addition of one or more auxiliary lightweight spreaders. The one below was designed by Charles E. Harris, of Raton, N. M. Its two arms are steel tubing, and the link consists of two pieces of strap iron. Pipe couplings will serve for the other parts. The fulcrum sleeve is adjustable and can be locked at any place by means of a set-screw. To the sliding sleeve is welded a set of bead jaws. Similar jaws are welded to the fixed fitting at the end of the tool.



HOW TO MOUNT TIRES

Partially inflate the tube before inserting it to prevent buckling

With your hand, guide the valve through the valve hole in the rim

Push the bead under the valve into the well at the center of the rim

Force the rest of this bead over the flange so it rests in the well

Now pry the top bead opposite the valve over the flange and, with a second tool, work around the rim

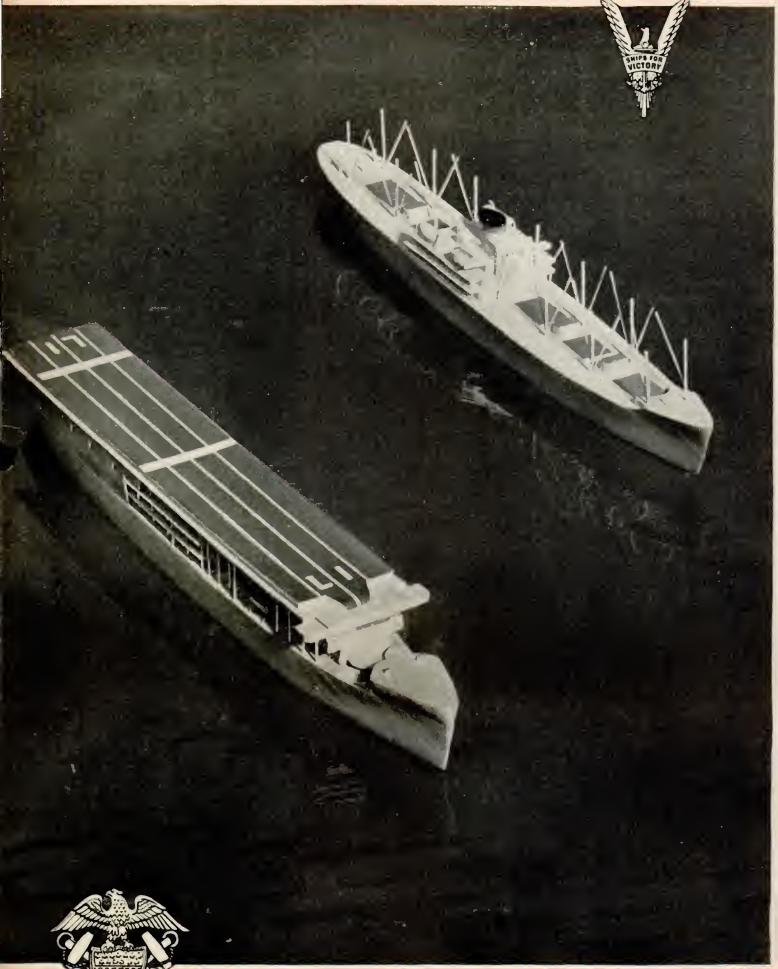
Seat the valve correctly, pulling it out by hand and centering it

Holding the valve, inflate until both the beads are properly seated

If there is a centering rib, have it show evenly all the way around

From Goodyear Tire & Rubber Company, Inc.

HOME AND WORKSHOP



Cargo vessels converted to plane carriers now do their part in guarding our supply lifelines. These models show a typical motorship before and after conversion

FROM

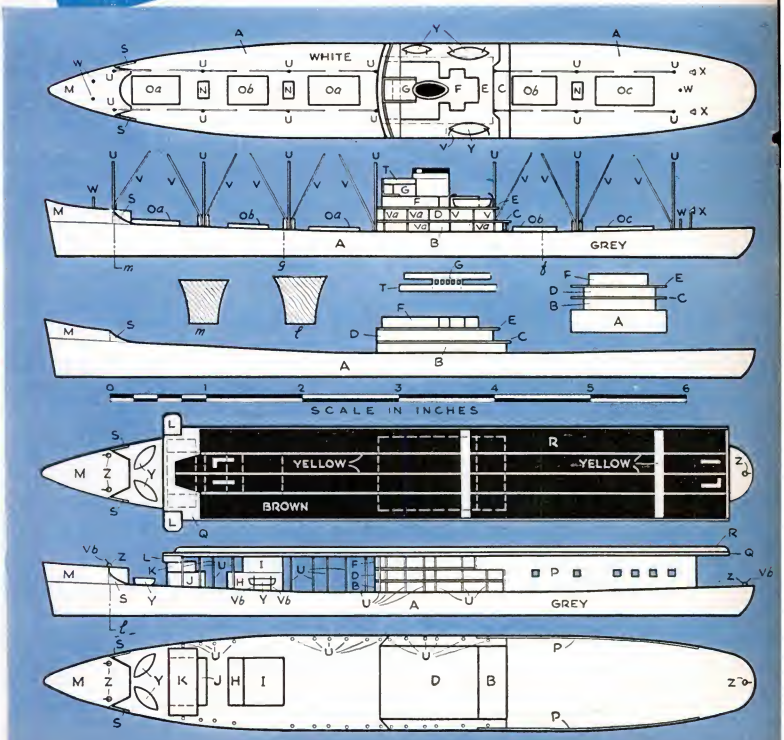
Peacetime Freighter to Fighting Carrier

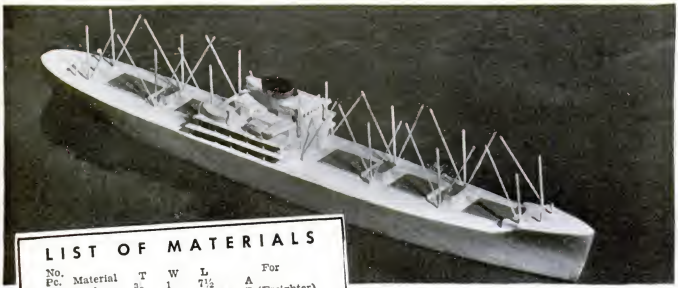
TWIN MINIATURE MODELS SHOW HOW AMERICAN INGENUITY ALTERS CARGO VESSELS TO ASSIST NAVY IN GUARDING VITAL WAR CONVOYS

By Theodore Gommi

TWO ship models in miniature—particularly fascinating projects for the home craftsman to tackle at this time—show how the U. S. Merchant Marine has come to the help of the Navy in furnishing craft for guarding other cargo vessels that carry arms and supplies to the A.E.F. and our Allies. Several motor freighters have been converted into efficient aircraft carriers—too slow for regular combat duty with swift-moving warships, but well fitted to accompany convoys and to provide an effective umbrella of fighter planes able to spot and destroy surface and undersea raiders even in the middle of the Atlantic.

The two models shown here are the





LIST OF MATERIALS

No. Pc.	Material	T	W	L	For
2	Wood	3/8	1	7½	A
1	"	1/8	3/4	1 5/16	B (Freighter)
1	"	1/8	3/4	1 7/16	B (Carrier)
1	Paper		1	1⅛	C
1	Wood	1/8	3/4	1 3/16	D (Freighter)
1	"	1/8	3/4	1 7/16	D (Carrier)
1	Paper		1	1¼	E
1	Wood	1/8	5/8	15/16	F (Freighter)
1	"	1/8	3/4	1⅛	F (Carrier)
1	"	1/8	1/4	5/16	G
1	"	1/8	1/2	9/16	H
1	"	1/8	7/16	½	I
1	"	3/16	½	7/16	J
1	"	1/8	5/16	11/16	K
1	"	1/16	3/16	1¼	L
2	"	3/16	5/8	1	M
3	"	1/8	1/8	3/16	N
2	"	1/32	5/16	½	Oa
2	"	1/32	7/16	5/16	Ob
1	"	1/32	5/8	5/16	Oc
2	Paper		7/16	2¼	P
1	Wood	1/32	1	5⅞	Q
1	"	1/8	15/16	5¾	R
4	Paper		Small Scraps		S
1	"		Small Scrap		T
14	Heavy Wire			1	U (Freighter)
28	" "			½	U (Carrier)
26	Light Wire			1	V (Freighter)
8	" "			½	Va (Freighter)
1	" "			2	Vb (Carrier)
3	Heavy Wire			½	W (Freighter)
2	Pins			½	X (Freighter)
7	Wood	1/8	1/8	½	Y
3	Small Beads				Z (Carrier)

Small piece of oval tubing for funnel.
White, gray, brown, black, yellow, and green paint.
NOTE: All dimensions are given in inches.

Water-line model of the freighter *Mormacmail* before conversion into an aircraft carrier

"before and after" of the S.S. *Mormacmail,* now an aircraft carrier in the service of the Navy as the U.S.S. *Long Island,* a motorship typical of the C-3 type freighters being furnished by the Maritime Commission for convoy-escort duty as aircraft carriers. In building both these models, it will be possible to see how the conversion was made from a ship of commerce to a ship of war. The scale used is 1" equals 66 2/3'.

After cutting wood, paper, and wire to the dimensions shown in the list of materials, shape the hulls, which are the same for both models. Note, however, that the forecastle *M* is higher in front on the carrier and is not cut back as sharply as it is on the freighter. The

U.S.S. *Long Island,* the converted *Mormacmail*

funnel on the freighter is for looks only since it is a motorship, and it is simply removed on the carrier to make room for the flight deck.

The carrier requires more work, especially in arranging the supports *U* for the flight deck. These must be inserted close to the edge of *A* in an absolutely vertical position. The bridge, *J*, *K*, and *L*, and the elevator housing, *H* and *I*, must reach the same level as the top of *F*. The deck, *Q* and *R*, is then glued to *F*, *I*, and *L*, and the supports *U* are trimmed to touch the underside of *Q*. The sides of the rear hangar *P* are cut from heavy paper or thin cardboard. The edges are glued to the extreme edges of *A* and to the underside of the flight-deck piece *Q*.

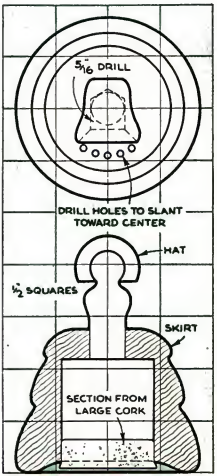
Boats and davits are attached in the positions shown. The AA guns are short bits of wire inserted through small beads.

In finishing the freighter, paint the sides of *A* and *M* gray and the rest white with the exception of the hatch covers, which are brown, and the funnel, which is yellow with green and black stripes.

The carrier is painted battleship gray except for the flight deck. This is medium brown with dark yellow guiding stripes and identification letters. If you prefer, you may glue on brown paper on which the stripes and letters are ruled with thin tempera paint and a ruling pen.

Salt and Pepper Shakers Reminiscent of Crinoline Days

Demure is the word for these salt and pepper shakers. The same design can be altered to make up into powder boxes



An evening's work at the lathe will produce these quaint little shakers, which can be made any size desired by drawing the pattern on larger or smaller squares.

Mount a piece of stock for each shaker in the chuck or on a screw center and bore out the inside with a small turning chisel, keeping the sides of the recess straight and square. Turn the bottom slightly concave.

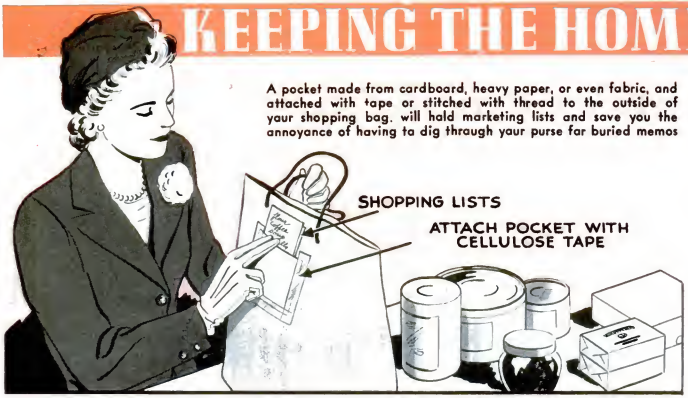
Next, turn a piece of scrap stock to a tight fit in the bored portions. Mount each piece on this mandrel to turn the outer contour and the top. If the stock is long enough, the peglike upper body may be turned from the same piece; otherwise, turn the upper part from dowel with a shoulder to insure its being glued squarely into a hole in the skirt.

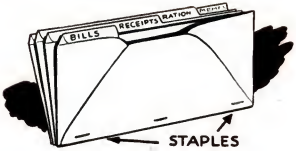
Dowel will also serve for the bonnets. Turn a short piece to the bell-like contour shown, with the wider diameter toward the tailstock. Run a 5/16" drill in from this end, flare the mouth, and cut off the piece. Saw off a narrow segment to form the bonnet, which is glued to the turned stem.

A French polish may be applied in the lathe, or the bodies may simply be stained and waxed. The bonnets may be painted white for salt and black for pepper. These condiments are sprinkled through holes drilled through the top of the skirts. Use a 1/16" drill for the salt shaker and a 3/64" drill for the other.—Bruce MacIntosh.

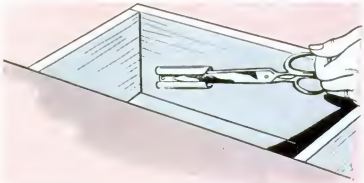
KEEPING THE HOME

A pocket made from cardboard, heavy paper, or even fabric, and attached with tape or stitched with thread to the outside of your shopping bag, will hold marketing lists and save you the annoyance of having to dig through your purse for buried memos



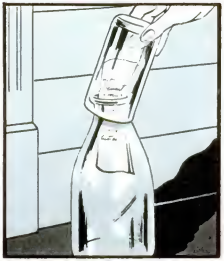


An inexpensive household file can be made by stapling together the bottoms of several large-size envelopes. Index tabs are formed by cutting the flaps and gluing them down



A short length of flat curtain rod tacked to the inside of a drawer will form a safe holder for your sewing or household scissors. The sides of the rod can be bent to hold shears of any size

The top of a scouring-powder can placed over a glass makes an ideal holder for starting small plants such as African violets

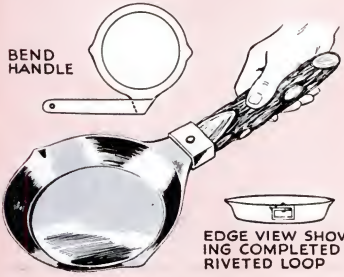


A note left in the milk bottle can be protected from rain and kept from being blown away by a glass inverted over the neck

An ordinary bottle cap nailed to a short wooden handle makes a good fish scaler. If desired, more than one cap may be used

SHIPSHAPE

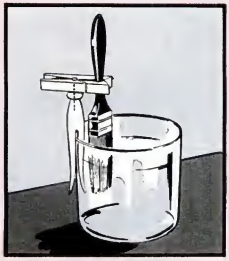
You can easily distinguish your own garden tools from borrowed ones, and also identify any tools that your neighbors may have borrowed, by painting all the handles of yours the same bright color



To make an easily packed camper's frying pan, bend the handle as shown above, then down, and continue to form a socket. Cut off any excess and rivet the joint. A branch whittled to fit the socket serves as a handle

Keeping the family's umbrellas conveniently in one place is easy if you build shelves inside a closet door as shown above. Holes are bored in the top shelf and the umbrellas inserted in these so that the tips rest in blind holes in the lower shelf. Before rolling umbrellas for storage, be sure they are thoroughly dry

The sharpened tips of a worn-out ruling pen will cut two parallel slits in paper, useful for holding stamps and like enclosures



One spring-type clothespin and one ordinary clothespin nailed together as above will form an adjustable paintbrush holder

Matches can be kept dry on fishing or camping trips if they are inserted in cellulose straws, folded, and made into packages

Wise Planning Helps You to Enjoy the Unrationed Outdoors

By JACK HAZZARD

MANY pleasures, especially long vacation trips, have been curtailed by war, but the great outdoors remains unrationed, and the enjoyment that can be derived from hikes and outings is unlimited, provided such ventures are carefully prepared for and equipment is judiciously selected. The following suggestions, which will help greatly in making life in the outdoors as pleasant as it is healthy, were culled from the writer's own experience and from a pamphlet published by the New York State College of Agriculture, Cornell University, Ithaca, N. Y.

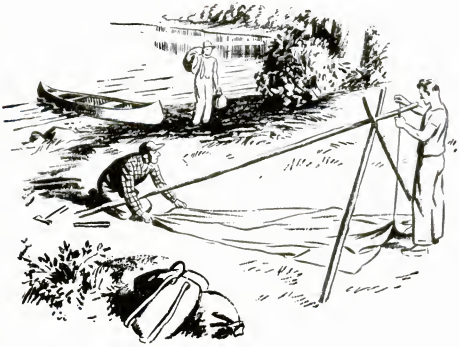
Hiking clothes should be comfortable and sturdy. Wear thick-soled shoes with soft uppers, and be sure they are large enough since you may have to wear an extra pair of woolen socks. Always equip yourself for rainy weather. A waterproof poncho is the best for this purpose, for it can be conveniently folded away when not in use.

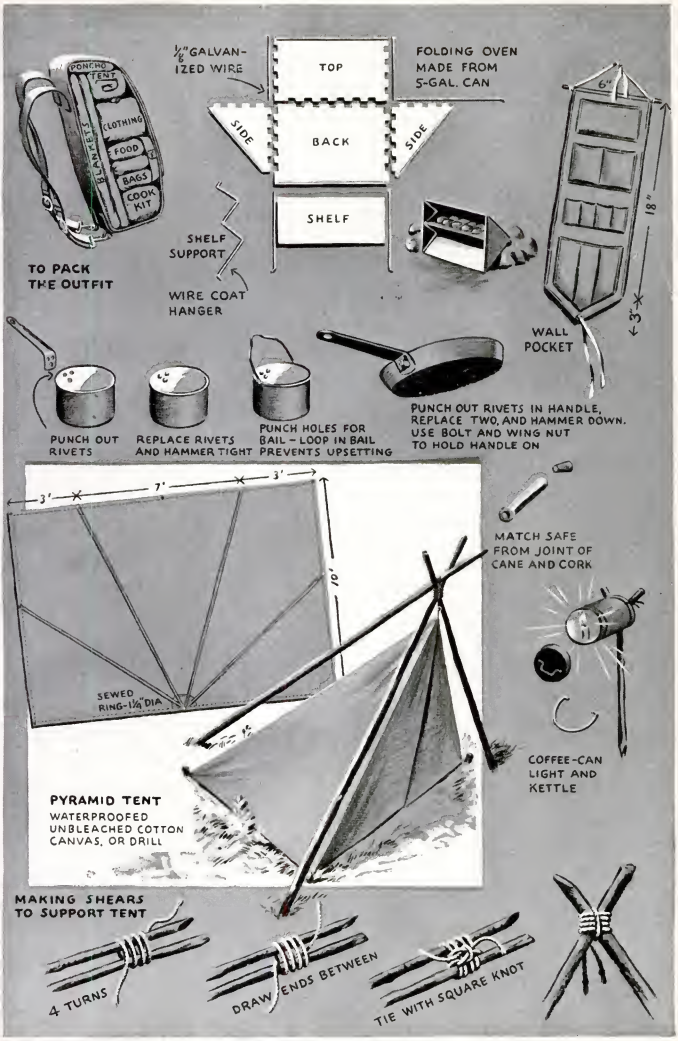
An easily made pack is shown in one of the illustrations. The material is 10-oz. duck sewed or riveted together. Web trunk straps make the best carrying straps, with the buckles arranged to permit easy adjustment. The pack when loaded should not weigh over one third of your own weight.

A hatchet or light ax is needed on even a short trip. The ax should have a sturdy handle—one as long as you can carry. Grind the edge to a long cutting bevel and keep it sharp, but never carry it in your belt without having a leather sheath over the cutting edge to protect yourself against serious injury in case of a fall. An ordinary jackknife will also be needed.

The tarpaulin shown in an accompanying drawing is made of unbleached cotton. The material should be shrunk before being made up, and then waterproofed. It makes a serviceable tent with a front flap that may be left open for sleeping in fine weather or tightly closed to keep out wind and rain.

To waterproof the tent, use two tubs or wash boilers. In one dissolve alum in hot, soft water in the proportion of ¼ lb. to the gallon. In the other, using the same amount of hot, soft water, dissolve sugar of lead (lead acetate—a *POISON*) in the same pro-




PONCHO
TENT
CLOTHING
FOOD
BAGS
COOK KIT
BLANKETS
TO PACK THE OUTFIT
1/8" GALVANIZED WIRE
TOP
SIDE
BACK
SIDE
SHELF
FOLDING OVEN MADE FROM 5-GAL. CAN
SHELF SUPPORT
WIRE COAT HANGER
6"
18"
3"
WALL POCKET
PUNCH OUT RIVETS
REPLACE RIVETS AND HAMMER TIGHT
PUNCH HOLES FOR BAIL - LOOP IN BAIL PREVENTS UPSETTING
PUNCH OUT RIVETS IN HANDLE, REPLACE TWO, AND HAMMER DOWN. USE BOLT AND WING NUT TO HOLD HANDLE ON
3'
7'
3'
10'
SEWED RING-1 1/2" DIA
PYRAMID TENT
WATERPROOFED UNBLEACHED COTTON CANVAS, OR DRILL
MATCH SAFE FROM JOINT OF CANE AND CORK
COFFEE-CAN LIGHT AND KETTLE
MAKING SHEARS TO SUPPORT TENT
4 TURNS
DRAW ENDS BETWEEN
TIE WITH SQUARE KNOT

CAMP CRANE
LIFT HERE
AND SWING

BACK LOGS
FOR BAKING

COCOA

POTATOES

BISCUITS
IN OVEN

CHOPS

WOODSMAN'S RANGE
CHOP PLACE LOGS
FLAT ON THREE SIDES

12"

36"

4"
LOGS

STONE REFLECTOR
(LOGS ARE GOOD)

PLACE LOGS 3'
FROM FRONT
OF TENT

HARDWOOD MAGAZINE FIRE
WILL BURN ALL NIGHT AND
KEEP TENT WARM

TREES MOST USEFUL TO CAMPERS

WHITE OAK (A)(C)(E)

RED OAK (A)(C)(E)

RED BIRCH (A)(D)(E)

MOCK HICKORY (A)(C)

SILVER MAPLE (D)(B)

TULIP (D)

SHAGBARK HICKORY (A)(C)

RED ASH (B)(A)(D)(E)

HARD MAPLE (A)(C)(D)(E)

RED MAPLE (D)(B)

YELLOW LOCUST (C)(E)

KEY
(A) FIREWOOD
(B) KINDLING
(C) COOK'S FITTINGS
(D) TENT POLES
(E) STAKES

portion. Let the solutions stand until clear; then add the sugar-of-lead solution to the alum. After four hours, pour off the clear liquid and work the tent in it with the hands until every part is thoroughly penetrated. Let the tent soak overnight, and in the morning rinse well, stretch, and hang it up to dry.

Comfortable brush beds can be made of twigs and boughs. Make the first layer of heavy boughs 2′ and 3′ in length. These are the "springs" of the bed. Smaller pieces are laid on next in overlapping shinglelike layers. The bed when complete should be approximately 2′ by 2′ by 6′. A lightweight, waterproofed canvas bag will also serve as a good bed. This may be stuffed with any soft material such as leaves, straw, rushes, evergreen twigs, and the like. A rough flooring of dead branches placed under the bag will make sleeping warmer and also provide a store of dry wood for the morning fire. The bag should measure about 2½′ by 6½′ when finished.

A piece of mosquito netting, hemmed and fitted with tie strings, is a seasonal requirement. It can be folded up in the tarpaulin for safe carrying.

Cooking utensils should be cut to a minimum, for they are too heavy and bulky to carry for great distances. Most important of all your cooking equipment is the frying pan. Be sure to choose one that has plenty of depth, for it can also be used to make stew or soup. Pans with detachable handles are good since they are easy to pack.

The folding oven shown in a drawing can be used to make biscuits or pastry, to heat canned goods, and to keep pancakes and the like warm. It was made from a 5-gal. square kerosene can, and when folded takes up no more room than a schoolboy's tablet. The size can be worked out according to the dimensions of the pack used and the material that is available.

Kettles for camp use should have broad bottoms rather than high sides. Two or three should suffice. Pack them with bags of supplies such as flour, corn meal, baking soda, coffee, powdered or canned milk, sugar, and other cooking needs. These, plus the oven and frying pan, are all the cooking utensils needed—but be sure to carry matches. Many a camping trip has been ruined because they were forgotten. The large kitchen matches are best, and they should be carried in a tin or waterproof container along with a piece of sandpaper that can be kept dry for use in wet weather.

One of the banes of camping is sunburn. Great care should be taken to avoid being burned unless your skin is accustomed to it. If you are mildly burned, treat the affected areas with a solution of cold tea, lemon juice, or vinegar before exposing yourself to the sun again.

Poison ivy and sumac are also sworn enemies of the camper. Learn to recognize both, and never make camp near them. A good preventive measure is washing the hands and other parts of the body that might become exposed to the poison with a strong alkali such as yellow laundry soap. A 5-percent solution of potassium permanganate painted on the skin will cure mild cases.

Nettles, though annoying, are seldom serious, for the sting passes quickly. If the camper moves through a clump of nettles very slowly he will seldom be stung at all.

Take along some simple remedies such as ammonia for insect bites, aspirin, and toothache wax. Sulphur tablets are good in chigger country.

Do not eat roots that have an "edible look"—some of them may be poisonous. And beware of toadstools! The really efficient camper should familiarize himself with various types of roots, herbs, and so on before he makes his trip.

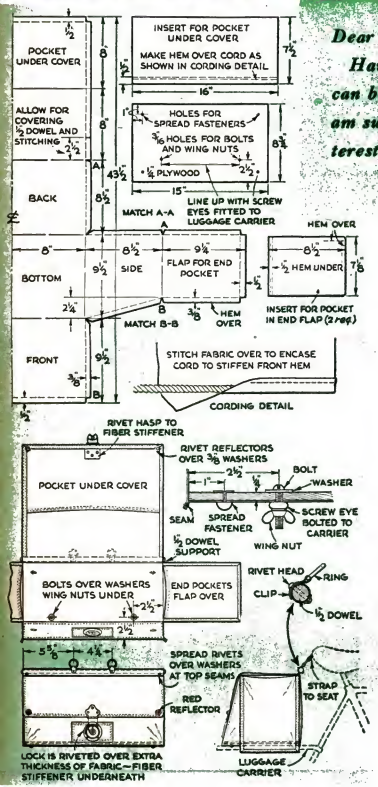
Hiking just for the fun of it is good fun and healthy exercise, but for the best enjoyment of a hike, no matter how long you intend to walk, have an objective in mind, plot out your course beforehand, then "go to it," a modern trail blazer—prepared for the worst—and the best.

All the above paraphernalia will actually fit into the bicycle pack. Included are a pup tent, raincoat, shaving kit, camera, blanket, and change of linen. Left, the completed pack in place on the carrier

Dear Workshop Editor:

Have you plans for a bicycle pack that can be attached to the luggage carrier? I am sure many other readers would be interested in such a pack now.

B. W., Salt Lake City, Utah



LIGHTWEIGHT, compact, and waterproof, this pack holds all the essentials for a bicycle trip and can be securely fastened to the seat and luggage carrier of any wheel.

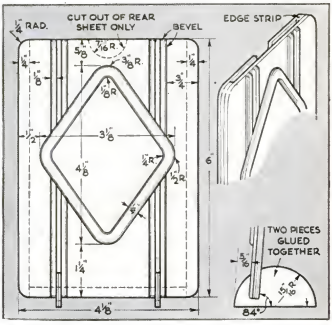
Waterproof artificial leather was used for the pack shown, but canvas, which you can waterproof yourself, may be substituted. A piece of fabric 43½" by 51½" is necessary. Lay out the full pattern from the half pattern shown in the drawing. Inserts for pockets should be cut from the waste material after the pattern has been formed. Before shaping the bag, the top front edge is seamed and a cord stiffener is pulled through the seam. The inserts for all the pockets are corded in like manner and stitched into the flaps on the flat material. After the pockets are stitched, the bag is French seamed with strong thread.

A plywood floor ¼" by 8¾" by 15" is fitted into the bottom of the bag and fastened with four roundheaded upholsterer's spread fasteners. The latter serve as casters when the bag is off the bicycle.

Two 3/16" holes are drilled through the plywood floor and fabric for the bolts, which rest on ¾" washers and are lined up with the screw eyes bolted to the luggage carrier. Wing nuts are used to adjust the bag and prevent side sway. The seat straps hold some weight, but the bag rests mainly on the carrier.—ERNEST R. DEWALT.

Enhancing the charms of the smiling miss above is the attractive frame made from show-card stock

Modernly Styled Picture Frame Made from Show-Card Stock



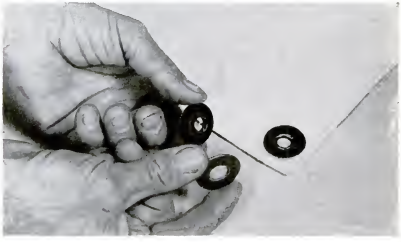
LIGHTWEIGHT yet rigid is this picture frame that is made from 14-ply show-card stock. A metal-edged ruler, a compass, and a penknife are the only tools needed to make it.

Using the ruler and compass, lay out the diamond-shaped center on a piece of cardboard and cut. Place this in position on the panel, as shown; then mark the inner lines of the center design and cut out the inside. Next, mark off the trimming strips from cardboard and glue in place. Be sure to bevel the edges of the strips and the cutout with fine sandpaper before gluing.

Strips of cardboard ¼" wide are glued at the sides and bottom between the front and back panels. The removable, semicircular bases are slipped on between the strips on the front panel. Smooth all the edges with fine sandpaper. If the picture or snapshot is too small to fit into this frame, it may be attached to thin cardboard.—FRANK SHORE.

Button Place Cards

BUTTONS and a few scraps of colored paper make amusing place cards. Features may be drawn on the buttons with India ink, as below, or the buttons may be sewn on with black thread that will form features. Cut petals from contrasting paper and draw on the stem.—B. N.

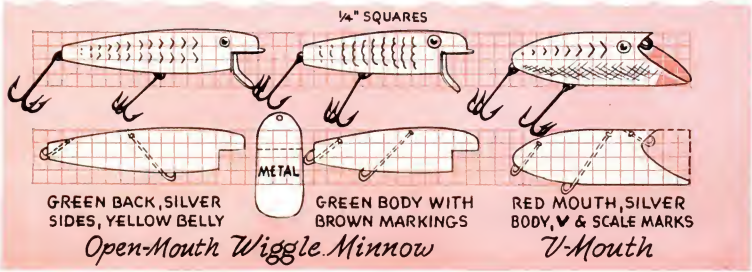


Film-Spool Ends Form Useful Grommets

GROMMETS for use on tents, auto covers, and the like may be made from the metal end of wooden film spools and ordinary ½" washers. Insert the spool end in a hole in the fabric, put on the washer from the other side, and clinch over the collar of the spool end from the washer side. To do this, place the round head of a carriage bolt on it and hammer the bolt, being careful to hold it steady. Such grommets, if carefully made, will hold securely.—B. N.

FISHING PLUGS

YOU CAN WHITTLE WITH A POCKETKNIFE



By ELMA WALTNER

LURES that will attract a fisherman as well as a large-mouth bass or a Northern pike can be made—if you know how to wield a pocketknife—in hardly more time than it takes to buy a new assortment for your kit. And even if you aren't a fishing enthusiast, making plugs can become an interesting and profitable hobby, for commercial lures command a good price.

While some of the newer ones in the sporting-goods shops are of plastic, most are of cedar—a lightweight, buoyant material when properly finished. A common white-cedar post—picked with an eye to as few cracks as possible—will furnish you with material for many lures. Cut 6" lengths and split them into pieces about 1½" thick. Whittle the body—or turn it if you prefer to use a lathe—to the size of the plug you plan to make. In whittling, keep the body as symmetrical as possible by turning the stock often as you work. But don't throw away your first crude efforts. They may prove to be the very plugs to arouse the fighting blood of the big ones when they land with an inviting "plop" beside the lily pads.

Double or triple hooks are the only parts you need to buy, and even these may be salvaged from old plugs. Hook loops and line loops are fashioned from nails. The nickel housing of an old alarm clock, or even a tin can, will furnish metal plates.

Finishing is important, but it need not be artistic. Give the plugs two coats of paint followed by two coats of spar varnish, sanding carefully after each coat has dried. If you wish to try your hand at a scale finish, dip a piece of veiling in dark paint and allow the surplus to drip off. Then, holding the veiling taut, lay it on the plug and immediately lift it off.

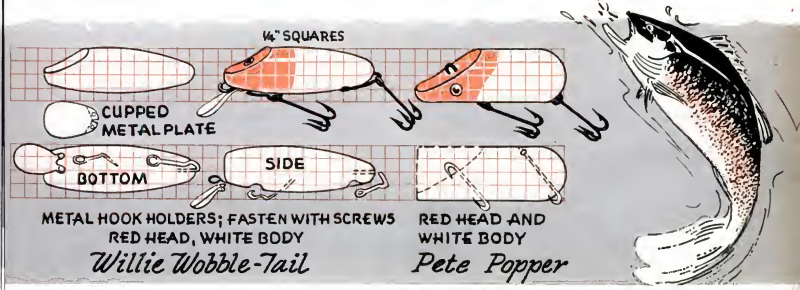
Perhaps the easiest plug to make is "Pete Popper," shown in an accompanying drawing. He floats on the surface when at rest, but "pops" and dives obligingly when retrieved with short, quick jerks. The hook and line loops on "Pete" are used on most of the plugs. Bore a hole of nail diameter on a slant from the top of the body to the tail and counterbore the upper part to take the nail head. Push the nail through as far as it will go, slip a hook over the point, bend the point upward with a pair of pliers until it touches the body, and then drive the nail into the wood. If the counterbore has been deep enough, the head will be perfectly countersunk and can be filled over with plastic composition wood.

The line and the hook on the bottom of the lure are held by loops made with the same nail. Select a longer nail than the one used in the tail and push it through a hole bored from the mouth. This hole need not be counterbored, and the nail head should project for about 1". Slip the hook over the point, bend the nail over, and drive the point deep into the wood; then cut the head off the nail, bend that end over, and drive it a short distance into the wood to form the line loop. Rustproof both nails with a coat of spar varnish.

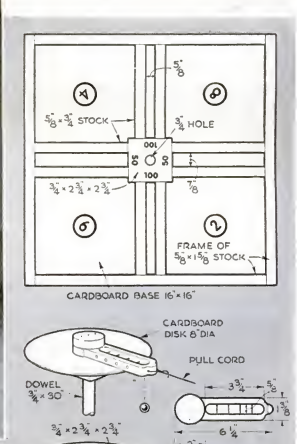
The V-mouth plug is a versatile fellow. He works equally well for trolling or casting. Two finishes are shown. It is hard to say which the fish prefer.

"Open-Mouth Wiggle Minnow" matches his name. He is streamlined and has a metal plate fastened to his head with four small nails. The two that pass through the top of the head are clinched for safety. A small hole in the horizontal projection of the plate is for fastening the leader snap.

"Willie Wobble-Tail" is perhaps the most complicated of the group. His hook fasteners were bent from heavy wire and fastened with small screws. However, the other type of hook fastener would be equally satisfactory. The line loop is bent from heavy leader wire. It passes under the metal plate and is fastened with the same screw that holds the forward hook loop.



Easy does it! The earnest lad standing up aims for his target as carefully as a bombardier who has just sighted Berlin



In the Groove . . .

CAN YOU SCORE FIVE PERFECT HITS IN THIS MARBLE GAME THAT CALLS FOR A KEEN EYE AND A STEADY HAND?

By MYRON FLEISHMAN

HERE'S a new game that will not only test your co-ordination of hand and eye, but will also provide good fun for everyone. Made of cardboard and wood, it is played with five marbles. The latter are dropped to the scoring board from a small tablelike disk by pulling a cord attached to a marble holder. This is pulled over the edge of the disk just far enough to release one marble at a time.

The base is cut from heavy cardboard and enclosed with four sides fastened with butt joints. A block bored to a snug fit for a ¾" dowel is glued or nailed to the center, and from each of its sides extends a slot made of two pieces of ⅝" by ¾" stock. Two opposite slots are ⅝" wide and are scored for 100 points, while the other two are ⅞" wide and score 50 points. These are the widths necessary when marbles 9/16" in diameter are used. Short dowel feet raise the base off the floor and keep the marbles from bouncing too high.

A heavy cardboard disk 8" in diameter has a block fastened to it to take the other end of the long ¾" dowel. The guide is sawed to the shape shown in the drawing, and the marble slot is cut out on a jig saw or with a scroll saw. Four nails through the slot form divisions for holding the five marbles, and a small hole is bored through the end for the cord. A circular piece glued to the round end of the guide adds enough weight to keep it on the disk when the end overhangs the edge.

The player stands 3' from the disk and maneuvers the guide in an attempt to drop marbles into the four narrow slots. Only one marble should be dropped into each slot unless the first four all reach their mark, in which case the fifth may be aimed for any slot except the one last scored.

Handle on Wooden Salad Bowl Makes It a Muffin Server

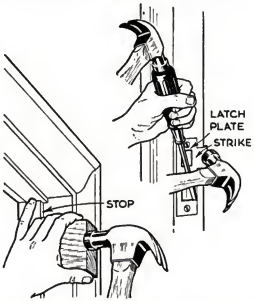
A QUAINT muffin server can be made of scrap materials and a small salad bowl from a five-and-ten-cent store. Select a slightly oval bowl about 8¾" by 9" and with a pleasing grain. Draw the outline of the top of the bowl on paper; then fold the paper in half to locate the spots where the handle will be attached with wooden pegs.

To make a peg, drill a ¼" hole in the end of a piece of ½" dowel and glue a short piece of ¼" dowel in the hole. Saw the ½" dowel off ⅜" long and the other so it projects ¼". Round the end of the larger dowel to form a head.

The handle can be made from orange-crate stock, a fruit-basket hoop, or maple or elm ripped 3/32" thick and ⅞" wide. Cut it a little longer than half the circumference of the bowl, round both ends, and bore ¼" holes about 1¼" from the ends. Soak the strip in tap water for 24 hours, following in boiling water for 30 minutes; then bend it wet on the rounded end of a board, and fasten. When dry, sand and shellac it before removing. It is attached to the flattened sides of the bowl by gluing in the pegs. Clean off surface oil if the bowl is to be decorated, and then shellac.—BERTRAM BROWNOLD.

In shaping the handle, soak it thoroughly and bend it over a rounded board until it dries. The sides of the bowl are flattened and bored to receive handle pegs made from ½" and ¼" dowels, as at the right

ADJUSTING LATCH PLATES [SHIPSHAPE HOME]



Door does not latch freely. Inspect the joint between the lock stile and jamb. If the door is greatly shrunk, the latch may not enter the plate far enough to catch. This can be remedied by placing cardboard shims behind the hinges.

Should rub streaks show that the latch catches the edge of the plate opening, drive the plate toward the streak with a hammer and the point of a screw driver bearing in the corner of the opening. If the plate cannot be driven sufficiently, remove it and file the opening. In extreme cases chisel out the plate gain and screw it back in a new position. Mortises that are too small should be enlarged with a chisel.

Pressure of one corner of a warped door against the stop may prevent entrance of the latch. Adjust the latch plate or drive the stop over with a hammer and block. Too much play will allow the door to rattle.

If the door rebounds when slammed, hammer back the projecting strike to provide better wedging action with the latch.

POPULAR SCIENCE MONTHLY SHOP DATA

Three

The two smaller tables slide on guides fastened under the tops to the side aprons. This makes it possible to pick up all three tables at one time

When nested, the tables make a neat appearance and occupy only a 16" by 20" floor area

NESTING TABLES STYLED FOR TODAY ARE PRACTICAL ACCESSORIES FOR ENTERTAINING IN THE SMALL HOME

FOR the moderate-size living room where tables are needed for multiple purposes on occasion, a practical and economical solution is a nest of tables. Three tables ordinarily take little more room than one end table, yet when the need arises they may be brought into the open for the use of guests.

As handsome as it is unobtrusive, the set shown here can be made in the home workshop from available materials. Success in building it demands chiefly the ability to glue up perfectly square frameworks.

These frameworks are the side-leg structures, which should be assembled first by doweling together the legs, side aprons, and bottom stretchers. Be sure they are held perfectly square while the glue is drying. Then join the pairs of frames with the back and front aprons. The back aprons are placed with their faces vertical, while the front aprons are placed with their faces in a horizontal plane. This permits the smaller tables to nest, as shown in the drawing.

The middle table is supported by its overhanging top ends upon two guides screwed to the insides of the aprons of the top table. The smallest table likewise hangs from the middle table. The overhang of all three tops is ½" on the sides and ⅛" on the front and back. When nested, the two smaller tables do not touch the floor. Fasten the tops on, as shown in the sketch, with screws extending upward through holes bored through the aprons. Round off all sharp corners and edges which might impair easy movement of the tables when they are being nested.

The set of tables shown in the photographs was made of scraps of walnut, the tops being glued up of several boards. Almost any wood, however, is suitable for tables of this design. Plywood, either ½" or ⅝" thick, can be used for the tops. Such nests of tables are also attractive in smooth paint finishes.

Tables in One

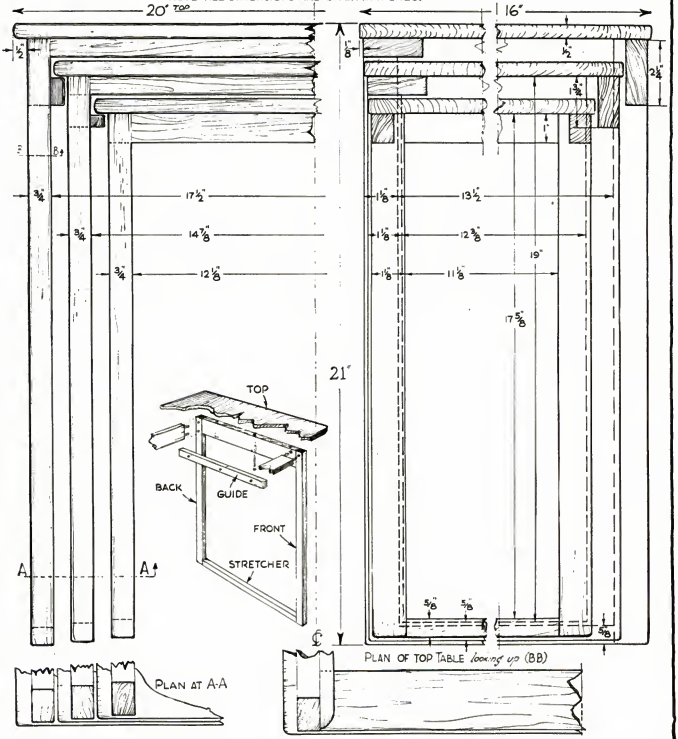
DESIGNED BY *Joseph Aronson*

List of Materials

PIECES	DESCRIPTION	THICKNESS	WIDTH	LENGTH
1	TOP	1/2	16	20
1	"	1/2	14 7/8	17 3/8
1	"	1/2	13 5/8	14 5/8
4	LEGS	3/4	1 1/8	20 1/2
4	"	3/4	1 1/8	19
4	"	3/4	1 1/8	17 5/8
2	SIDE APRONS	3/4	2 1/4	13 1/2
1	BACK APRON	3/4	2 1/4	17 1/2
1	FRONT "	5/8	2	17 1/2
2	SIDE APRONS	3/4	1 3/4	12 3/8

PIECES	DESCRIPTION	THICKNESS	WIDTH	LENGTH
1	BACK APRON	3/4	1 3/4	14 7/8
1	FRONT "	5/8	2	14 7/8
2	SIDE APRONS	3/4	1	11 1/8
2	FRONT AND BACK APRONS	3/4	1	12 1/8
2	STRETCHERS	5/8	3/4	13 1/2
2	"	5/8	3/4	12 3/8
2	"	5/8	3/4	11 1/8
2	GUIDES	1/2	1	14 3/4
2	"	1/2	1/2	13 5/8

NOTE: ALL DIMENSIONS ARE GIVEN IN INCHES.



AIDS TO WARTIME *Housekeeping*

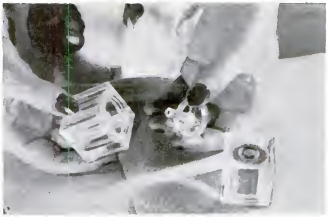
ADJUSTABLE SHOPPING BAG. It folds into a 7" by 7½" handbag with a side opening to hold small packages. When fully opened, as at right, the bag measures 18" by 18". It is made of sturdy cotton rep with strong felt handles

THERE'S NO RUBBER in these erasers! Made of vegetable oils processed with chemicals, they will neither smudge nor tear the paper

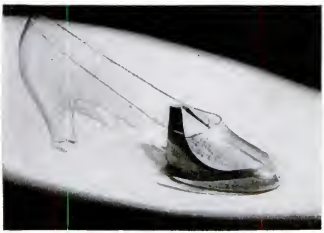
TASTELESS TABLETS preserve the natural coloring of fruit such as bananas, plums, pears, apples, and peaches that have been cut for use in salads and the like. Simply dissolve one of the tablets in a quart of cold water, immerse the fruit for about 30 seconds, drain, and place in a refrigerator. Fruit so treated will keep its original color several days

A WOODEN JAR SEALER, shown below, fits over the top of any standard jar. Only a small amount of pressure is required for perfect sealing. A metal stud on the inside rim of the sealer molds the flange of the lid into the jar rubber. With this handy device, old lids may safely be used again and again. Save for the stud, no critical materials are used

WOODEN DUSTPANS are on the market as substitutes for hard-to-find metal types. Well built and nonwarping, they last as long as their predecessors. Shaped exactly like the metal ones, the dust catchers come attractively finished in red, black, green, or blue enamel to match or harmonize with other kitchen furnishings. One household size is available



PLASTIC SALT AND PEPPER SHAKERS. Besides adding a decorative touch to a table, these unique shakers are moisturepraof and nonbreakable. The opening rests on the table, thus preventing the entrance of air into the salt or pepper chamber. They contain no metal parts for salt to corrode



SHOE TREES made of a noncritical cellulose material fit into the toe of the shoe, as shown above, without stretching the sides or straining the stitching. They are scientifically designed to allow free circulation of air inside the shoes

SOAP FOR WOOLENS in the form of a faintly scented, jellylike preparation has appeared on the market. It is added to lukewarm water, and wool washed in it and dried properly, according to the makers, retains its original softness and fluffiness

LIQUID CEDAR. You can cedar-line a closet or a chest with this liquid that is painted, sprayed, or brushed on wood or paper surfaces. It retains its fragrance and does not evaporate, thus repelling moths and other harmful insects. A pint bottle of the liquid will cover approximately 200 sq. ft.

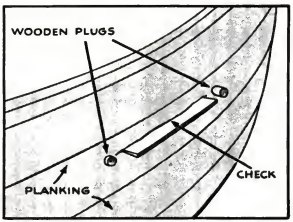
WITH THIS HOME DEHYDRATOR, you can prepare foods for storage even if you live in a small home or apartment. A table lamp with a 300-watt bulb in it provides adequate heat for dehydration. The fiber-and-hardwood cabinet contains five trays that hold the prepared fruits and vegetables. In it, 25 lb. of tomatoes can be dried to 1½ lb., or 25 lb. of apples to about 4 lb., and stored in a proportionately small space. Such dehydrated food is prepared for use by soaking it in water

BOAT HINTS

by J. A. Emmett

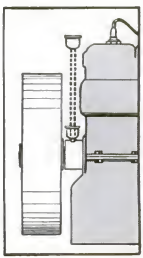
ATTENTION TO THE SAILS and running gear of your sailboat will yield dividends in longer life. Turn halyards and sheets end for end to keep them from wearing at the same spots. Mutton tallow applied to ropes where they rub against block sheaves will reduce wear there. If your sail slides aren't swiveled, leave some play in the marlin servings to avoid strain.

Mildewproof your sails with a waterproofing compound made for the purpose. Ease off the main halyard so that shrinkage in wet weather won't stretch the luff of your sail. When using reef points, tie them in such a way as to distribute the strain of the filled sail evenly along its foot. Such precautions, together with those shown in the sketches, will delay replacements and may prevent failures in use.

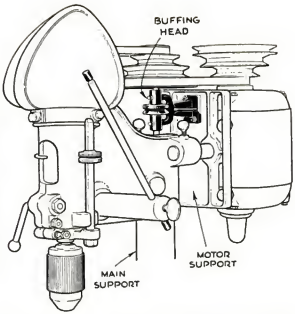


CHECKS IN PLANKING AND DECKS never get better of their own accord, and filling or caulking forces the opening to widen and extend at both ends. Instead, drill a hole at or just beyond each end of a check, its size in proportion to the thickness of the plank—3/16″ for the average ⅝″ or ¾″ material. Make cedar or pine plugs a snug fit for the holes, dip them in waterproof resin glue, and tap them in, but not too hard. After 24 hours saw them off and tackle the check itself. If this is small, fill it with thin resin glue, working it well down, but if it is wide, shave off a strip of cedar or soft pine the length of the check, coat this with glue, and press it in. Dress off any excess the next day.

GREASE CUPS in inaccessible places on an outboard or inboard engine will be easier to service if extended by the use of pipe fittings. Screw a short or long pipe nipple in the cup hole, add a coupling or elbow, and screw the cup on the end. Oil holes may be tapped to take a length of small pipe or tubing, straight or bent. As an engine's parts become worn and grease cups require turning down oftener, these extensions will lesson the danger of burning one's fingers.



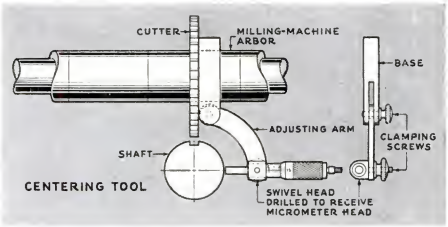
New SHOP IDEAS



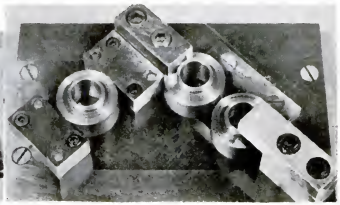
EXTRA DRILL-PRESS SPEEDS are easily obtained by the use of a jackshaft made from an ordinary buffing head. Drill holes in the motor support in order to bolt the buffing head to it, removing the cap of the drill-press column if necessary so that the shaft may extend into the column. If this is impossible, it may be cut short. Mount a step pulley on the shaft and reverse the one on the motor. Both V-belts should be loose enough to shift on the pulleys without undue strain. With this setup, it is possible to obtain very high speeds for shaping and routing, or extremely slow speeds for heavy drilling.—WILLIAM J. PRITCHARD.

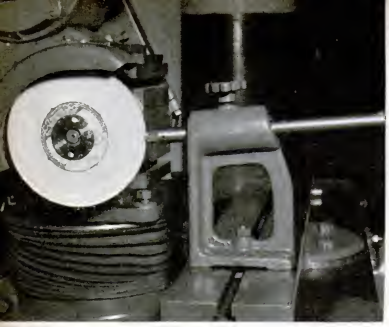
A CENTERING GAUGE that will quickly align a shaft under a milling cutter, or level work in the vise of a machine, can be made from a micrometer head and a few pieces of scrap steel. The swivel block at the lower end of the adjusting arm is bored to an accurate fit for the micrometer barrel. Two screws and milled clamping nuts lock all three members rigidly together.

To locate a milling cutter directly above a shaft or a gear blank, for example, the base of the centering tool is placed against the face of the cutter, and the arm and block are locked with the micrometer spindle close to the work and at right angles to the base. The micrometer is then adjusted until the spindle contacts the side of the work, and the reading is carefully noted. With the gauge against the opposite face of the cutter, the micrometer is again adjusted to contact the shaft on that side, the difference in the readings is noted, and the cross-feed screw is adjusted accordingly in either direction in order to center the work.—H. D. CHAPMAN.



WOMEN WORKERS play an increasingly important part in the nation's war production, and are making their share of suggestions for speeding Victory jobs. Mrs. Helen Bering, an inspector at the Ternstedt plant of the General Motors Fisher Body Division, suggested a three-in-one gauge for checking dimensions of bearing cups. Formerly three snap gauges were necessary, and it took one hour to check 290 cups. Now one gauge plate makes it possible to check the dimensions of 538 bearing cups an hour. The photos below show both the old and the new gauge setups.





Above, a diamond truing tool in correct position supported close to the point to minimize overhang

A tool-grinding wheel can be dressed by holding an abrasive stick against its rotating surface

TRUING GRINDING WHEELS

MACHINE grinding is the most scientifically accurate method of producing cylindrical, conical, and plane surfaces and of duplicating machine parts. In order to achieve this precision, however, grinding wheels must be perfectly trued. How this may be done is described in an article by E. T. Larson in "Grits and Grinds," a monthly publication of the Norton Company, from which the following pointers and the accompanying illustrations were taken.

All types of abrasive wheels, with the exception of diamond wheels, may be dressed with diamond tools. A dressing tool of this kind consists of one or more stones mounted in a holder, which is traversed across the face of the wheel while the revolving wheel is fed against it.

Mount the tool rigidly and with minimum overhang to avoid chatter, and also be sure that all sources of vibration have been eliminated from the grinding machine itself. The tool should be canted at an angle to the wheel face pointing in the direction of wheel travel. For this "drag angle," a maximum of 10 to 15 deg. and a minimum of 3 deg. are safe margins.

Remember that a diamond dresser is a precision tool. Avoid subjecting it to sudden shocks and blows, turn it frequently in the holder to keep it sharp, and when the diamond has worn badly return it to the manufacturer for resetting.

Before truing is begun, the wheel spindle bearings should be warmed up so that dressing may be done under normal grinding conditions. The dressing operation may be either wet or dry, but it should be the same as that of the grinding. Start truing at the highest point on the face of the wheel, which will usually be at the center, and take light cuts—never more than .001" for finishing. Let the diamond cool between cuts.

A slow traverse gives a high finish, but if it is too slow, it will cause the wheel to be glazed. A fast traverse produces a free-cutting wheel, but one that is too fast may leave diamond marks that will be transferred to the work. During any one pass, a uniform rate should be maintained.

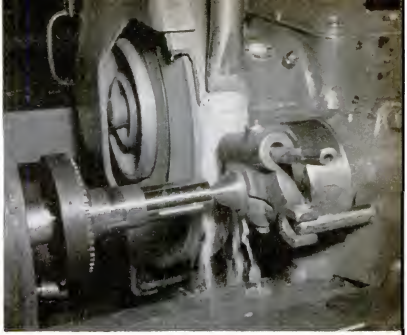
Cluster-type diamond dressers give better results if traversed faster than the single-point tools. When the diamonds wear down level with the matrix, the dresser can be reconditioned by rolling it up and down and from side to side against the face of a 60- or 80-grit, soft-grade, silicon carbide wheel until the diamonds are again exposed.

In truing for rough grinding, the wheel is fed into the diamond about .001", and the diamond is traversed at medium speed. Truing for finer finishes requires reduction of the traverse to the slowest speed consistent with the finish desired. The feed should also be lessened, and for very fine finishes, it is advisable to make the last two or three passes without any feed.

Because of high wheel speed, diamond wear may be relatively rapid on a thread-grinding job. The diamond, therefore, must be turned and adjusted frequently. Light truing usually results in less diamond wear, and any temptation to employ a heavy feed, even when a wheel has worn excessively, should be scrupulously put aside.

Truing of thread—grinding wheels should be done with a fairly large stream of lubricant. Three types of diamonds are

Occasional use of an abrasive stick on a metal-bonded diamond wheel will keep the surface clean



A good flow of lubricant is necessary in truing a wheel on a cylindrical grinder as shown above

FOR PRECISION WORK

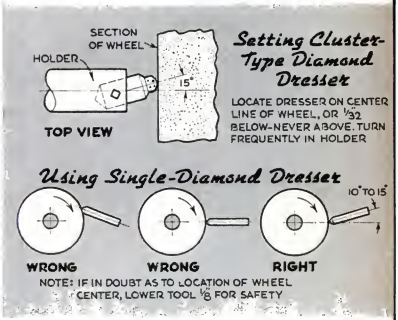
used, one for each sloping side of the V-face and a third for the "flat" at the apex. The width of the wheel at the apex should be slightly narrower than the width of the flat or root of the thread to be ground so as to permit some radial wheel wear.

All shapes of grinding wheels used for tools and cutters can be dressed with an abrasive stick held in the hand, but for truing newly mounted wheels or for reshaping the face, a diamond tool should be employed.

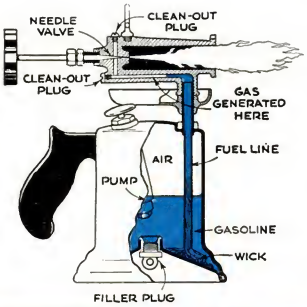
Metal-bonded diamond wheels for offhand sharpening of cemented carbide-tipped tools should be dressed with the abrasive stick that is supplied by the manufacturer. It scours the metal bond without disturbing the diamond particles, and its occasional use will keep the surface clean and sharp.

If this dressing is neglected until the wheel cuts slowly and heats the tool, the wheel should be dismounted and rubbed by hand on a flat iron plate sprinkled with No. 180 abrasive grain. The entire operation takes only a few minutes and will clean out a wheel that has become severely loaded with steel ground from the shanks of carbide-tipped tools. Resinoid-bonded diamond wheels should be cleaned only with a piece of lump pumice such as that sold by paint shops.

Should it become necessary to grind the periphery of a diamond wheel to restore its face, the truing operation can be done by mounting the wheel on an arbor between centers in a cylindrical grinding machine. Use an indicator to see that it runs true. Rotation should be at the slowest available speed, and grinding is done wet with a soft-grade, medium-grain abrasive wheel.



To dress a badly worn metal-bonded diamond wheel, rub it on an iron plate dusted with abrasive grain



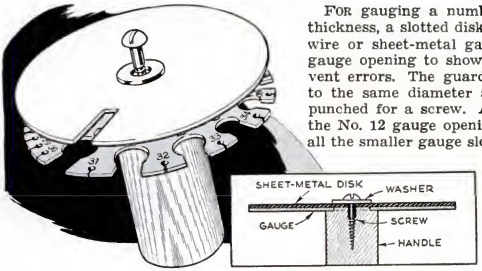
Drawings by William Patrick.

ABC's of Blowtorch Use

LIKE many another tool, a blowtorch is safe if used with care—dangerous if misused. How a blowtorch works is shown at the left. Air pressure forces gasoline up into the generating passage, which is kept hot enough by the flame of the torch to vaporize the fuel. A needle valve controls the flow of the vapor through a small orifice into the burner, where it draws in air to form a combustible mixture.

Keep the torch out of drafts while gasoline in the drip cup is burning. Pump up air pressure after the torch is lit to obtain the desired flame volume. It is a good idea to release air pressure after shutting off the torch. Empty and rinse out the fuel tank occasionally. For safety, do this in the open air.—J. MODROCH.

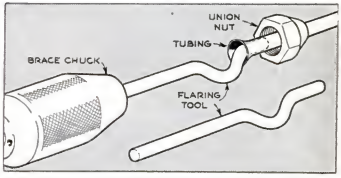
Slotted Guard on Wire Gauge Prevents Errors in Measuring



FOR gauging a number of parts of the same thickness, a slotted disk mounted over a standard wire or sheet-metal gauge will permit only one gauge opening to show at a time, and thus prevent errors. The guard is cut from sheet metal to the same diameter as the gauge and center-punched for a screw. A slot slightly wider than the No. 12 gauge opening will serve for this and all the smaller gauge slots. As shown, both gauge and guard are screwed to a piece of broomstick for ease of handling. A larger slot can be cut opposite the first for gauge openings Nos. 0 to 11.—RONALD EYRICH.

Flaring Tool for Copper Tubes Can Be Made from Heavy Wire

IN REPLACING gasoline lines or installing other small copper tubing, it is necessary to flare the end in order to make a tight fit with the union nut. A simple emergency tool for this purpose can be made from a piece of heavy wire of smaller diameter than the internal diameter of the tubing. Bent as shown and rotated inside the tubing by means of an ordinary brace, this forms a smooth, even flare. Care should be taken not to make the elbow bend too sharp.—R. E.

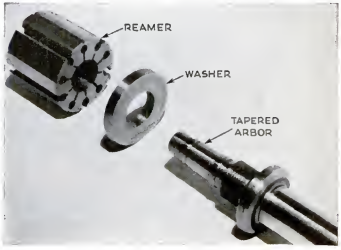


Ordinary Eraser Holds Small Brads Safely for Easy Starting

A COMMON long eraser, as shown in the photograph at the left, makes a simple device for protecting your fingers when starting small brads. Both ends should be slit back about ¼″ without cutting away any of the rubber. This will provide a flexible grip that will pick up the brads and hold them for starting. As the slit wears, shave the eraser back and deepen the slit so that it enters fresh rubber.

New Production Reamer Speeds Work in Restricted Quarters

A NEW production tool developed by Henry Bernadt, of the General Electric works at Schenectady, N. Y., not only reams holes in places difficult to reach with ordinary tools, but also has an adjustment for compensating wear. The reamer is a steel cylinder with multiple cutting edges on its outer surface that ream to specified tolerances at a single turn. Longitudinal slots permit an expansion of .002″ when the tapered arbor is tightened against the washer after the reamer is inserted in the hole. These slots also compensate for cutter wear. By decreasing the thickness of the washer .001″, the arbor penetrates deeper, expanding the reamer .0001″.



Precision Woodworking with

By EDWIN M. LOVE

SMALL carving motors and flexible shafts are excellent tools for model making, carving, and light grinding. Equipped with special stands developed by the manufacturers, such motors are capable of accurately reproducing in small scale the work of a lathe, jointer, router, and shaper. Should the home-workshop owner desire to build his own accessories, satisfactory substitutes for the manufacturers' stands

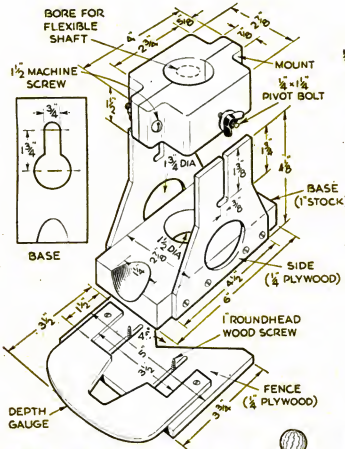


Fig. 1 UNIVERSAL MOTOR STAND

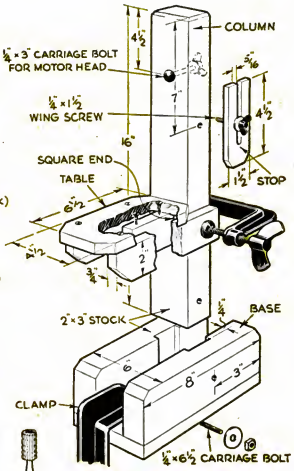


Fig. 2 ROUTING STAND

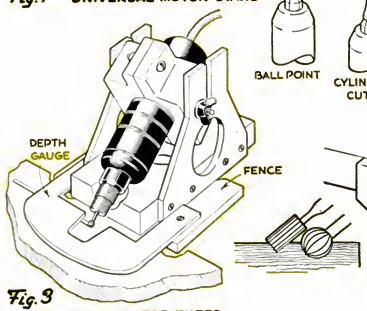


Fig. 3 VEINING WITH MOTOR TILTED

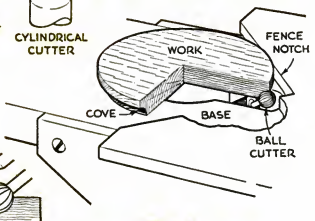


Fig. 4 SHAPING WITH MOTOR TILTED UNDERNEATH

Small Carving Motors

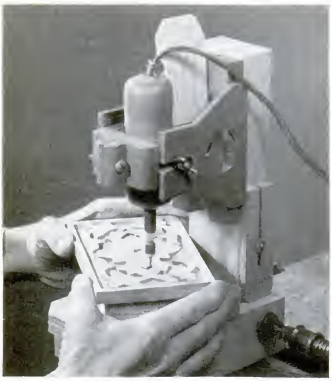
Mounted on a stand built as shown on the facing page, a carving motor can be used for many delicate operations in craftwork. Here a border is being veined on a panel with a small ball cutter in the chuck

can readily be made from sound hardwood.

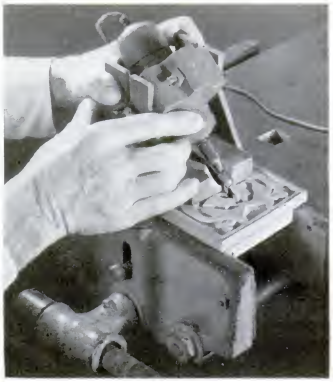
How are these stands built? A universal stand adaptable to any small carving motor or flexible shaft is shown in Fig. 1 and in the photograph above. Slight alterations, such as a change in the size of the motor-mount hole or in the height of the sides, may be required for your particular carving motor. Make the motor mount from a piece of 2" by 3" stock 4" long. Use an expansion bit for boring the motor hole, setting the cutter by first making test cuts in scrap pieces. Saw the mount into halves and counterbore the pivot-bolt holes at the inner ends so that the boltheads may be sunk flush.

The holes in the sides give visibility, and the L-slots, cut to allow easy entrance of the pivot bolts, provide for clamping the motor mount at various heights and also for lengthwise adjustments of the base. Bore the base to admit the cutter, extending the hole toward one end to allow tilting of the motor. Gouge a trough at the opposite end to clear the chuck when the motor is used in a tilted position. The fence is straight on one edge and notched on the other. Fasten it to the base with two screws passing through washers or a thin yoke and the adjustment slots. The depth gauge is screwed to the top of the fence.

To increase the usefulness of the mount, make a routing column and table as shown in Fig. 2 of the drawings and in the photo at top left on the following page. The column can be held upright in a vise when in use, but a base that can be clamped to the bench may be built for it. A stop on the



Its motor mount bolted to a column, the carving motor routs out the background of a low-relief carving. The push button is held in by a wedge



Mounted on a universal stand, the motor is tilted to plane down the level of the carving. A ball point cuts best when tilted, if the work permits

side of the column makes it possible to replace the table at the proper height if it must be removed for adjustment of the work.

Can a small carving motor be used in making full-sized furniture? One job it does easily is veining, which means cutting a shallow, rounded groove in the face of the work to form a border, to separate a light-stained area from one stained dark, or to make a decorative line design. Mount the motor in the universal stand in a vertical position with the tip of a 3/32" ball cutter projecting below the base by half of the diameter of the cutter. Set the straight edge of the fence to gauge the distance of the vein from the edge of the work, and mark the starting and stopping points of the lines with a pencil. Start the cut by pressing the fence against the guiding edge and lowering the tool until the base rests on the work. Then push the stand along the edge of the work to the end of the line. A second pass of the cutter without change of setting makes a smoother job.

To cut a border vein on circular work, reverse the fence and use the notched edge as a guide. Veining of intricate designs is best done by using the column and patterns especially cut for the work.

Ball points, in any but small sizes, cut poorly on the ends because of the meeting

Rabbeting a strip with the motor upside down and a cylindrical cutter set in a notch in the fence

Shaping the edge of a disk is done with the motor tilted to bring the side of the cutter into action

of the cutting blades at a dead center. For this reason it is advantageous to tilt the motor in the stand, as in Fig. 3 and in one of the photographs, when the work permits. The cutter, projecting at the end of the base, will be in full view and can be accurately adjusted for depth of cut by varying the tilt of the motor. The fence, fitted with its depth gauge, makes the scoring of lines parallel to the edges easy and rapid. Without the fence, the tilted cutter is efficient for shallow routing when it is not necessary to have vertical sides in the cut.

How is the routing stand used? Bolt the motor stand to the column and set the column upright in the bench vise. Insert the motor mount with the motor shaft parallel to the column. Loosen the column stop and locate the height of the table by resting the work on it and sliding it up until the cutter projects the correct distance below the top of the work. Then clamp the table and set the stop against it.

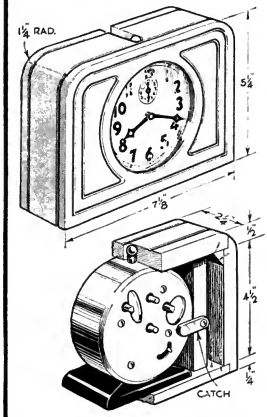
A small cylindrical cutter with scored teeth works best for routing, but it does not bore well, and therefore a hole should be drilled to depth in the center of each area to be routed. To insert the cutter in the work, loosen the table clamp and swing the front edge of the table down until the work can be placed under the cutter. Raise the table to position against the stop and clamp.

Begin routing by feeding the work lightly against the rotation of the cutter until the blades graze the outline, steadying your hands against the table and manipulating the work with your fingers. The cutter will tend to slip into the routed area instead of gouging into the outline, thus giving positive control. Work as closely into the corners as possible. When the cavity is routed, lower the table and reset it for another. The corners can be carved out with a chisel.

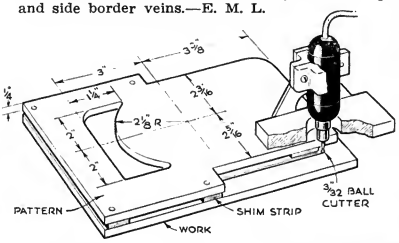
How is intricate veining done? This is easiest with a jigsawed pattern placed over the work and raised above the cutter blades with shims so that the shank will bear against the edge of the pattern and will be guided by it. The pattern must be accurate, for all irregularities will be transferred to the work. If the pattern is an outside one, cut its edges larger by half the diameter of the shank; if it is an inside one, cut the pattern correspondingly smaller. Soap the edges to reduce friction.

What setup is used for operating the motor as a shaper? Insert the desired cutter and set up the motor as for routing without bolting the stand to the column. Clamp the stand upside down, as in Fig. 4 and in two of the photos. Adjust the straight edge of the fence for straight work and the notched edge for round work. When cutting coves, use a ball cutter with the motor tilted to take advantage of side cutting. Make two or three passes on heavy cuts.

Decorative Clock Case Veined with a Carving Motor



MAKE a dual pattern for the front of the clock case with one end an outside template for the panels and the other an inside guide for the border. Cut stock oversize so that the pattern, laid on shims, can be nailed to it in waste wood, and align with a nail thrust through a hole in the center of the pattern and the work. Run the carving motor around all edges; then pry up and reverse the pattern for completing the front. Assemble with glue and, when it is dry, run the top and side border veins.—E. M. L.



Privateer That Started the U. S. Navy Is Prototype for This

Schooner Weather Vane

HISTORIANS tell us that the first armed vessel to sail under the authority of the Continental Congress was the Marblehead schooner *Hannah* commissioned by George Washington as a privateer. While there are no scale drawings of the *Hannah*, research has given fairly accurate information on her size and general appearance. This weather-vane model follows these specifications, omitting only those details that would be indistinguishable on a mounted vane.

The over-all dimension of the model hull, including the stem, is 12¾". Use 1" or 1⅛" stock, preferably the latter. If light-gauge zinc is not available for the mainsail, any 8" by 8" light sheet metal, or even wood, will be satisfactory. The rigging is 22-gauge copper or galvanized wire fastened to the hull by winding it around partly driven pins that are later driven home.

Make a template for one side of the hull and mark the outline on the stock along with lines for painting and locations of masts, guns, and pivot bearing. Shape the hull with square edges; then saw a ¼" slot for the stem-keel-rudder part, as shown by the dotted lines *B-C*, *C-D*, and *D-E*. The edges are next rounded on both sides, but only to the top of the green stripe at the stern, which is square from this point to the deck. A rounded bow and square stern are important features of the design.

Manned by soldiers of the Continental Army, the schooner *Hannah* sailed out of Beverly, Mass., on September 5, 1775, with a commission from George Washington as a privateer. Her first prize, the British ship *Unity*, fell to her the next day. Above is a copy of a woodcut of the *Hannah* in the book *Origin of the American Navy*, by Henry E. White, which was published in 1890

Drill the two ¼" holes in the hull for the masts at a slight angle from the vertical toward the stern; then bore two ¼" holes through the hull for the guns. The bowsprit is glued into a hole drilled into the bow. Use special care in drilling for good alignment fore and aft. Lay out the entire stem-keel-rudder piece on ¼" material to fit the slot sawed in the hull. Glue this piece in place and sand the hull smooth.

The masts and bowsprit are tapered from ¼" dowels, and the main boom, main gaff, fore boom, and fore gaff are tapered from ⅜" dowels. Tapering begins about one third of the way from the base, and can be done with a block plane and then sanded smooth. Give the entire hull a priming coat of flat white and two coats of enamel, coloring the stripes as indicated. The spars and bowsprit are stained brown, and the guns are black. A final coat of spar varnish will provide additional protection from weather.

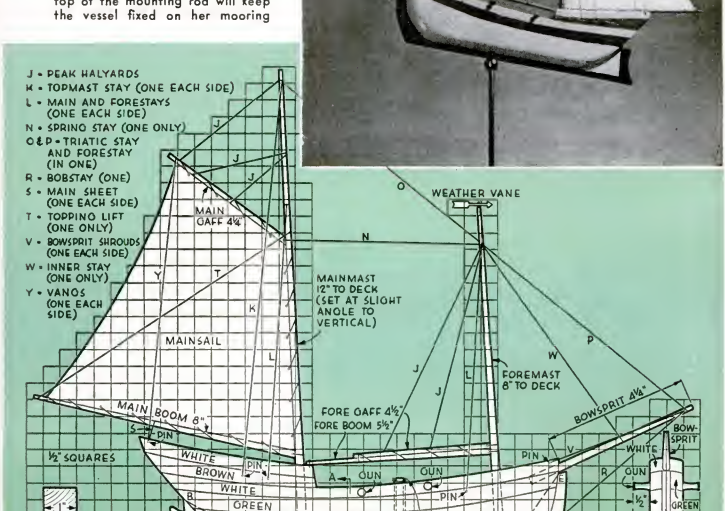
The mainsail is cut to shape and small holes are punched along three edges for bending it to the mast, boom, and gaff with copper wire. File any burrs caused by punching; then give the sail two coats of flat white and one of glossy white enamel.

Shape the ends of the booms and gaffs to fit the curve of the masts at the angles shown in the drawing. Drill a small hole through the main boom at this end and start the wire around the boom and through the holes at this point, keeping the sail in the center of the boom and the wire pulled taut. Bend the sail to the main gaff in the same manner after most of the rigging has been done, further adjusting the stays if the weight of the sail requires it. Fasten the fore gaff to the fore boom with a brad, lash them together, and tack the end to the deck.

To hold the schooner for rig-

By Harry D. Hamilton

Mounted where it will receive the full effect of undeflected wind, this model of the historic *Hannah* heads proudly into the breeze. A cotter pin through a hole in the top of the mounting rod will keep the vessel fixed on her mooring



ging, set the shaft bearing over a large nail driven through a wide board. Drill small holes in the masts and bowsprit for fastening wires and in the hull for stay and vang pins. Triatic stay *O* and forestay *P* are made of one wire which goes through the foremast on a slant. Forepeak halyard *J* is also one piece of wire, as are the lower *J*'s on the mainmast and the *L*'s and *K*.

Attach all the rigging wires as shown, leaving ends long enough to be adjusted before final fastening. Adjust all wires for tautness and neatness; then make them fast and drive the pins in carefully. Wire ends can be soldered for strength and neatness.

The weather vane on the foremast is made of a piece of celluloid about 1" long. It adds a touch of authenticity.

Gay Designs Add Sparkle to

BRIGHT NEW THINGS FROM DISCARDED OUT-OF-DATE PIECES WILL GO FAR TOWARD FRESHENING YOUR HOME SURROUNDINGS

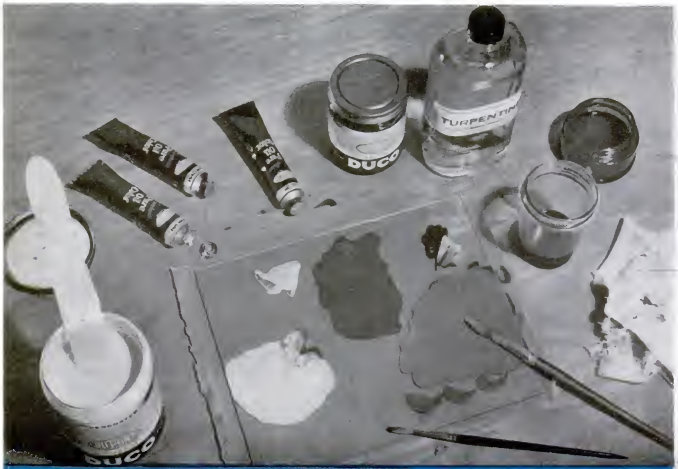
WHEN you are digging old pieces of furniture from the attic in the hope of salvaging enough to make that spare room livable, try your skill at freehand decoration. It is surprising what it will do toward rejuvenating a hopelessly outdated bureau, chair, or even bed. With a little alteration in addition to the repainting it is highly possible that you will like a done-over piece so much you will promote it to the best rooms in the house.

While the painted decorations on furniture appear—and are—easy to do, they stem from basic principles of technique, as shown on the facing page in the sampler of Peter Hunt, of Provincetown, Mass. This illustrates several fundamental brush strokes that are used singly and in combinations to make any number of motifs. Fruits, flowers, conventional designs, and even vegetables evolve from these simple strokes. It is fun to do, and it is surprising how many attractive original designs will flow from your palette when you become acquainted with the freehand use of small, pointed, camel's-hair brushes measuring from ⅜" to ¾" in length.

Oil paints, available in small tubes and a variety of colors, are used for this fascinating work. The paints can be mixed and blended to make any shade desired, and white can be added to make softer tints. Oil colors are thinned for use with a little turpentine and clear varnish. This makes application easier and drying quicker. Squeeze oil colors first on a palette, which may simply be an old plate or a piece of glass, mix them as desired, and then apply them to the furniture.

Because several colors may be used in combination to make a design, it is necessary to let each dry sufficiently so that it will not mix with the subsequent coat being applied near it or, as in many cases, over it.

Try this new way of decorating old pieces that you have salvaged and rebuilt.



Decorating requires only a few tubes of oil colors, turpentine and clear varnish, and a small palette. Above, a piece of window glass serves as a palette. The gray paper under it provides a neutral background. Keep a glass of turpentine near by for cleaning brushes between colors

Old Furniture

Here is an old oil lamp that was wired, painted white to reflect light, and then decorated in gay colors and hung over a dining-room table. Left, a charming chest decorated with a vegetable motif

Photos and sampler courtesy E. I. du Pont de Nemours & Co.

BASIC DESIGNS TO HELP PERSONALIZE YOUR FURNITURE

Even if you can't draw, study and copy this sampler for decorations that will brighten up your discarded furniture. They require just a few fundamental strokes with a camel's-hair brush and, used singly or in combination, will achieve surprising and fascinating transformations

Folding

TAKES THE DRUDGERY OUT OF WARTIME MARKETING, SAVES GAS AND TIRES

THIS sturdy and attractive shopping cart will help take the drudgery out of transporting purchases home from stores. Its tricycle wheel arrangement makes for ease in crossing curbs and allows the cart to stand alone. A shaped bag, 12" square and 21" high, made of waterproofed canvas, will fit the cart and keep a miscellany of small packages safely together. Ties at the back support it upright, and a wire bent to fit inside the seamed top edge holds the bag in shape.

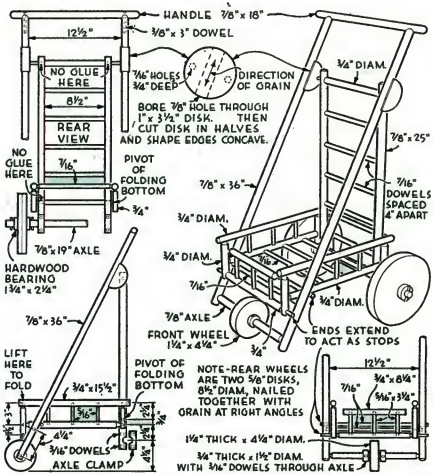
The shopping cart is made almost entirely of dowels. Wheels are of hard yellow pine. Bearings for the large wheels are made of a hardwood such as maple and soaked in oil or hot wax. The maple dowel axle is given the same treatment, which assures squeak-free action for some time.

When not in use, the cart folds to a thickness equal to the diameter of the large wheels and can be tucked away in a closet. Final assembly should be made only after all the parts have been trial-fitted. Use a good grade of waterproof glue for all joints. A first coat of primer paint followed by two coats of enamel will provide a lasting finish.

A hardwood bushing that has been soaked in hot paraffin is driven into each wheel

Two collars are slipped on the front axle and doweled close to the wheel to maintain its central position on the axle

Shopping Cart



Benjamin Nielsen designed and built this folding cart to be the last word in accessories for the home shopper who does her own delivering. The color might be natural or enameled

SEPTEMBER CHECK LIST [*SHIPSHAPE HOME*]

1. If basement is wet, dig outside trench and lay tile drain.
2. Dampproof cellar walls before fall wet weather.
3. Reset loose chimney bricks and capping with cement mortar.
4. Repair and paint storm windows and doors.
5. Install weatherstripping on window and door frames.
6. Enlarge fuel bin if necessary. Put in winter supply.
7. Build a cool, ventilated fruit and vegetable room.
8. Replace all loose or cracked glazing putty.
9. Take out broken window panes and install new ones.
10. Inspect sash cords. Replace any that are frayed.

POPULAR SCIENCE MONTHLY SHOP DATA

Designed for Service...

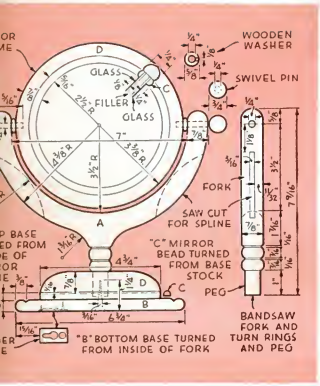
DRESSER AND WALL MIRROR. This double-faced swivel mirror with a walnut frame and base is useful on a dresser or as a shaving mirror on the wall. Cut the bottom of the base from inside the fork, so as not to waste stock, and turn a piece to go on top of it from within the mirror-frame ring. Turn the bead for the inside of the frame from the stock of the bottom of the base, which is then finished in the lathe.

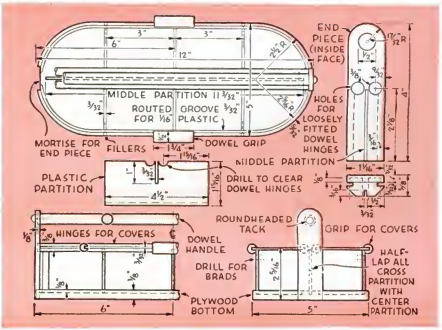
Mount the fork in the lathe and turn the two rings and the peg at the bottom; then slot the fork for splines. Drill swivel-pin holes in line, using a snug filler piece between the prongs.

Turn the frame to the Gothic shape shown in the cross section, making the opening to fit the double-faced mirror to be used. Drill swivel-pin holes on the center line; then glue in the bead over the glass.

Bore carefully through the upper part of the base and into the bottom for the fork peg and

. . . CRAFTWORK PROJECTS BY





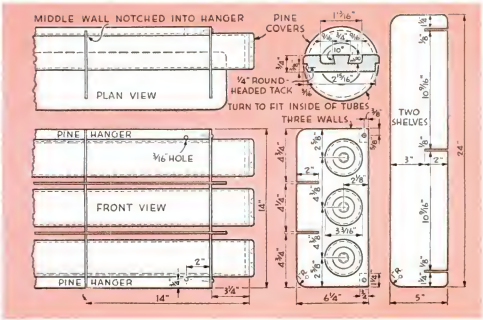
drill a 3/16″ hole through the center of the bottom for the wood screw, counterboring for the head. Install the hanger plate with the grain of the bottom. Turn the round-head pins and the washers, and assemble with the washers between the fork and frame. Working time: 6 hours.

PLASTIC BUTTON BOX. The plastic covers, sides, and partitions show at a glance the buttons available. Cut the birch-plywood base, sand smooth, and rout grooves for the sides and partitions. Make two endpieces of maple, using a generous length for ease in handling when cutting slots. Drill holes for the handle and dowel hinges ½″ deep, cut the 45-deg. chamfers, shape the tops, and sand. Mortise the base for the endpieces; then groove the hinges and cut to length.

Clamp the three short plastic partitions between two pieces of wood and pass them across a circular saw for half-lap joints. Drill ⅜″ holes through a wood jig, as shown, making semicircular cuts in the plastic to clear the hinges. Cut the long partition and saw out half-lap slots.

Assemble the partitions and cement them into the grooves in the base. Fasten the endpieces in place, fitting in the hinges and handle. Bend the plastic sides after immersing them in hot water and fit them into the grooves in the endpieces and base. The dimensions of the sides are 1 15/16″ by 13½″, and the top corners are rounded to clear the hinges. Brads join the sides to the cross partitions. Cut the plastic covers, leaving a lip on each for slotted dowel grips. Cement these in place to complete the assembly. Working time: 6 hours.

ERNEST R. DEWALT ARE PLANNED TO FILL REAL NEEDS

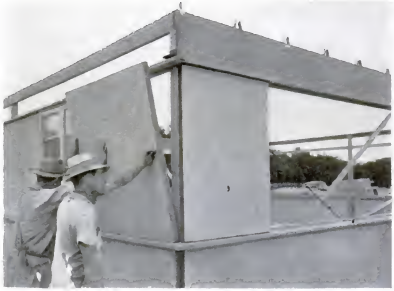


DRAFTSMAN'S SHELF. Scrap pine, three cardboard mailing tubes, and 4 sq. ft. of ⅛″ composition board are used for this shelf and tracing holder. Cut three 28″ lengths of mailing tube of uniform diameter. Brad the three walls together where the half-lap waste area will occur, and with a circle cutter make holes for the tubes in all three at once. Lap joints are then cut, and the corners are rounded. Drill screw holes in the outside walls and notch the middle wall to fit the saw cuts in the hangers.

Make two shelves, cutting slots as shown, and round the corners. Fit them to the walls, saw out the hangers, and screw the parts together for a trial fit. Remove the hangers to drill and counterbore for the screws.

Stain the wood pieces walnut and varnish them; then paint the tubes black. Between coats, turn the six tube covers, making the inside shoulders a slip fit for the inside of the tubes. Reverse the covers in the chuck, turn the knobs and recesses, and finish with walnut stain and varnish. Working time: 5 hours.

A SEAT AND WASHER combination now on the market not only provides a watertight seal for household faucets, but—as shown in the drawing below—it also eliminates the need for using a separate washer and screw. When installed, it expands and locks tightly in the faucet. Suitable for use in both cold and hot-water taps, the device is available in all of the standard sizes.



WALL PANELS made of a fiber insulation-board core, sealed with a special compound between two layers of asbestos and cement, are being used in homes under construction for war workers. One panel on each side of the framework replaces the sheathing, building paper, and siding or lath and stucco formerly used in wall construction. The product affords ample insulation and can be used with standard sashes and doors.

A DRY WALLPAPER CLEANER, shown in use below, literally "erases" dirt from the walls. Consisting of tiny particles of art-eraser gum enclosed in a porous cotton bag, it requires no special skill, but is merely rubbed gently over soiled surfaces. The cleaner will not cake, dry, or smudge, and is safe to use on all types of wallpaper. It can also be used successfully on window shades, white shoes, lamp shades, felt hats, books, pictures, etchings, paintings, Venetian-blind tapes, and the like. It is available in one handy, easy-to-grip size.

CIRCUIT-BREAKER PLUG. Replacing the conventional receptacle plug usually found on the connecting cord of small electric power tools, office machines, home appliances, heating devices, fluorescent light fixtures, and the like, this device breaks the circuit when a short circuit, motor stall, or accidental ground occurs. Protection is provided not only for each individual piece of equipment on a circuit, but also for the circuit itself—that is, faulty operation of one device need not affect others on the same line. To reset the plug after a circuit break, simply pull it out and lower a lever, which will have sprung from between the two prongs, back into place. This circuit breaker will do much to eliminate dangerous fire hazards and costly repair bills, and is also valuable in shops to prevent breakdowns.

OF INTEREST TO HOME OWNERS

PLASTIC HINGES are now being used by one aircraft manufacturer on boxes for airplane tools, cases for maps, charts, radios, and the like. Chosen not only because they save essential war metals, but also because they are extremely light in weight and durable, the hinges are said to withstand long, hard wear without denting, chipping, or cracking, and their smooth, lustrous surface is rustproof and dirt resistant. Strips may be cut to any desired length and are easily attached to other materials by means of adhesives, rivets, or screws. They can be made in many colors, and they offer endless possibilities in the designing and manufacturing of light and portable equipment. Such hinges may, in the near future, replace metal ones in a variety of light-duty applications.

THIS SOIL-TESTING KIT, consisting of about 60 strips of chemically treated paper and a color chart for comparing results, comes conveniently packed in a 3" glass tube. The paper, after being inserted in a slit in the ground made with a knife, changes color according to the condition of the soil. Its hue is then compared with the chart to determine whether the acidity or alkalinity of the soil is such that will need correction.

LEAN-TO BASEMENT GREENHOUSE. You can raise flowers and vegetables the year around in this greenhouse, which is easily erected alongside an open basement window. Constructed of red cypress and double-strength glass, it comes semiassembled and can be put up in less than a day. It is available in three, four, and five-section units measuring from 4′ 4″ to 7′. Entrance is possible through a door at the end or through a cellar window. In winter, heat from the basement provides the proper temperature, but on extremely cold days a small kerosene stove or electric heater can be used.

HOSE HORSE FOR GARDENS. Simple in construction, the all-wood "horse" shown above holds the hose in such a manner that a spray or stream can be directed on the area desired. By simply adjusting the rear leg, the hose can be placed in any position. The device is covered with a water-repellent wood preservative and comes knocked down, with easy instructions for assembling. It can be set up without the use of screws or nails.

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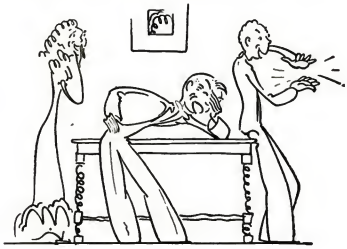
HAVE you ever repeated a scene until, through its very repetition, your audience laughed uproariously? That's what Hollywood calls a "running gag." Have you ever stopped motion, varied your filming speed, or reversed action by filming a scene upside down? Professional productions, including the newsreels, employ all these ruses to get laughs.

There's no reason why home movies, adopting the same simple technique, can't provide merry as well as informative shots of the family and friends. Laughter is an important morale builder, and it doesn't cost a cent. There's no need, either, to make elaborate setups or produce involved continuities, for with a few twists of the wrist the camera will make your scenes funny. Professional movie makers build comedy from situations and dialogue. But you needn't worry about writing funny lines; just produce situations—some with your people, others with your camera.

Take the running gag, for instance. No trickery is involved in it. You need only straight shots to liven up your little document. Suppose you plan to film a summer picnic at the park. Show your friends pitching horseshoes, playing ball, swimming in the pool as usual, but at intervals make a few shots of Dad on the spring board. Have him walk out on it, then change his mind and return to his easy chair. The first sequence should show the entire routine, from chair to board to chair. No one will laugh at this, for this is Dad's regular ritual. Then shoot successively shorter scenes of each appearance, until you show only his feet as he stands on the board, with his toes wiggling apprehensively. On his last appearance, return to a medium view, and have him walk out to the end, pose, lose his balance, and splash into the water.

Running gags need not be funny in themselves to get a laugh. Repetition alone becomes hilarious. One of the dignified men at your party, for example, repeatedly tries to light his pipe, only to have the match blow out. Or one of the young ladies attempts to powder her nose, without success because the breeze blows the powder from her compact. For the "payoff", the man takes a pipe, already lighted, from his pocket and calmly proceeds to smoke, while the girl gives up and tosses her compact aside.

One way of giving your movies an



Long a specialist in directing children, Charles Lamont makes frequent use of the laugh-getting methods he describes in this article. They add punch to his latest Universal Studios picture, "Oh, Doctor," starring Abbott and Costello. Stop-motion in the sequence below lets a new child, and finally a dog, be put in the barrel after each climbs out. It looks like magic

Putting Laughs INTO YOUR Home Movies

BY CHARLES LAMONT
DIRECTOR, UNIVERSAL STUDIOS

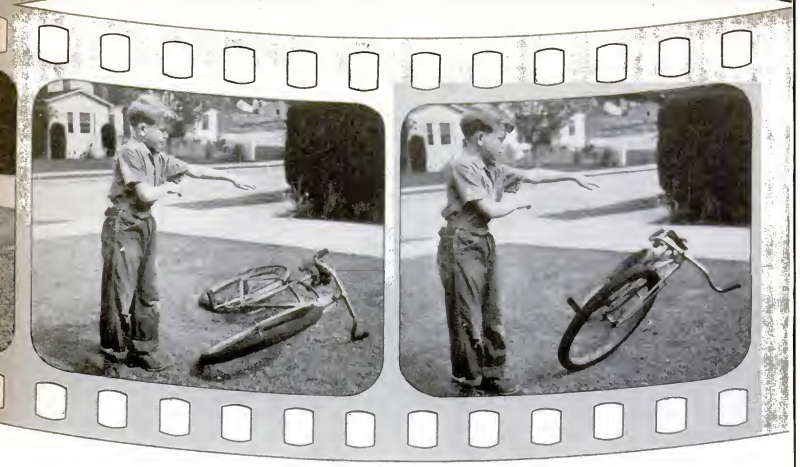
amusing twist is by interrupted action. This is a way of making things happen on the screen that you know can't happen, but which your eyes insist can. It is accomplished by stopping the camera, changing actors or props, and then shooting again.

Using this trick, you can have a lot of film fun with four or five children and a barrel. Set up your camera for a medium shot of an ordinary barrel. Plant the first child inside the barrel and make a shot of him emerging and taking a position alongside it. Stop the camera and put the second child in the barrel. Take him coming out, stop the camera again, and repeat the same procedure until all the children have been taken. You probably will want to title this one "The Magic Barrel" or some such name, as it will seem that only by some act of legerdemain could so small a barrel hold so many children. It is essential, however, that you set your camera on a tripod or some other steady support, and see that no one disturbs it during the entire time.

The newsreels frequently use stop-motion to emphasize speed. For example, they show people racing out of a subway station to the opening game of the World's Series or scooting across an intersection as a traffic cop waves his arm like a berserk semaphore. This effect is achieved simply by cutting camera speed in half. An occasional flick of the exposure lever makes the scene look like a panic. Even everyday scenes can be made humorous this way.

Set your camera at half speed and make some shots of the youngsters playing about the house. When you project the film on the screen at regular speed, they will seem to be moving at a breakneck rate. Follow this with a normal shot of Mother calling them for their baths; then double the camera speed to slow them down to a snail's crawl as they answer the summons. Many variations of this idea will occur to you.

Don't forget, though, that changes in speed require accommodating changes in exposure. Every change in stop doubles or halves the exposure. If, for instance, you shoot a scene at standard speed at f/8, the diaphragm should be set at f/11 for half



speed, or f/6.5 for double speed. Slow motion heightens interest in many subjects. A calf chases baby across the garden. When the calf is taken at half speed to make its galloping seem faster and the baby in slow motion in order to stress her danger, you have a simple but effective formula for a mirthful sequence.

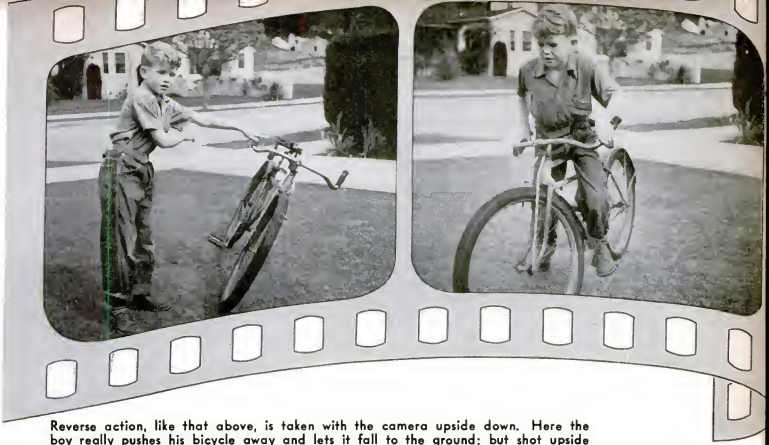
In the same way, upside-down filming offers many opportunities to provide silly sequences. This is also an old newsreel chestnut. Remember those episodes in which a diver slid feet-first from the water, tumbled upward to land on a high spring board, and walked backward to the platform? All you need do to take such a sequence is to place your camera upside down and make the exposure as the subject walks out and dives off the board in the usual way.

A simple application of this, to show Junior with extraordinary control over his bike, will make the bike appear to get up off the ground and roll into his hands when he whistles for it. Turn the camera upside down and make a shot of him pushing the bike away. The wheel rolls over and falls on the ground. Now turn the camera over to the normal position and take him standing and whistling as if for the bike. Stop the camera, have someone hand him the bike, and then make a normal shot of him riding away.

When the first shot is cut from the roll and sandwiched top side up between the other two, it will look on the screen as if the bike had come up from the ground at Junior's command.

In trying this stunt with two or more persons, you must have them appear throughout in the correct order from left to right. There's nothing to worry about if you have a 16-mm. camera. When you cut the picture, simply turn the inverted strip end for end with the same side of the film facing you. However, with 8-mm. film it is necessary to reverse the faces of the film when it is turned end for end in order to keep the perforations on the proper side. For this reason, reverse motion cannot be made on 8-mm. film when more than one person ap-

Upside-down shooting will make the tossing away of an armful of bric-a-brac look like a series of humorous catches when the film is projected. Possibilities are limitless



Reverse action, like that above, is taken with the camera upside down. Here the boy really pushes his bicycle away and lets it fall to the ground; but shot upside down, cut from the film, and then turned and spliced, the sequence makes it appear as if the wheel rises at his command. He is photographed normally as he rides off

pears in the scene, since two or more will seem to change places.

All sorts of gags can be brought off by this time-tried stunt of reversed action. For example, dispute your wife's skill as a cook by making egg yolks jump back into their shells, cake batter flow back into the mixing bowl, steaks (if any) leap from the broiler up to her hands. Water soaking Dad's Victory garden can be made to appear to drain back into the hose and leave the earth dry.

Here's another stunt: Have your subject hold an armful of objects such as a vase, a pitcher of water, and one or two other fairly fragile things, and toss them one by one to someone outside the picture. He should use a straight-arm technique, tossing the objects up as well as away from himself and finishing with the palm of his hand open and facing upward. Filmed upside down, this stunt will give every appearance of a series of catches. It will be breath-taking. A similar sequence in which knives are seemingly caught would be especially so.

Did you ever want to stand on the cowcatcher of a train or the front of a street car and film the tracks as the vehicle rolled along? You can do just that, and easily, if you take your position on the rear and shoot at the receding track with the camera upside down. And to "prove" you actually made such a hazardous sequence, have someone grab shots of you climbing on and off the cowcatcher and run these as the introductory and closing scenes. But be sure to reverse the scenic strip!

Jumping offers good reverse-action possibilities. Little Johnny probably can't jump over fences without falling. Stand him on top of a fence and, with the camera right side up at a 45-deg. angle to the line of jump, make a shot of him leaping forward. Then have him jump backwards from the same spot on the fence and run backwards from where he lands while you shoot him with the camera inverted. Reverse this last scene, splice the two, and you have an excellent sequence showing Johnny clearing an obstacle higher than his head.

These trick shots are intended to get laughs, not to build up feature productions. Nonstandard camera speeds, upside-down filming, repetition, and stop-motion are methods, not materials, and require none but natural props that are available to everybody.

Subjects are too numerous to name. Divers, hurdlers, long-distance runners, golfers, tennis players, soldiers on parade—slow motion will show their form and add interest to their performances.

Simply pick out your subject, apply the technique you desire, and you'll be producing short subjects the like of which have never before been recorded by your camera.

Accurate weighing with this small beam scale will help the amateur photographer get better results in his home developing and printing

DARKROOM SCALE

BUILT FROM WORKSHOP ODDS AND ENDS

By ROGER MOYER

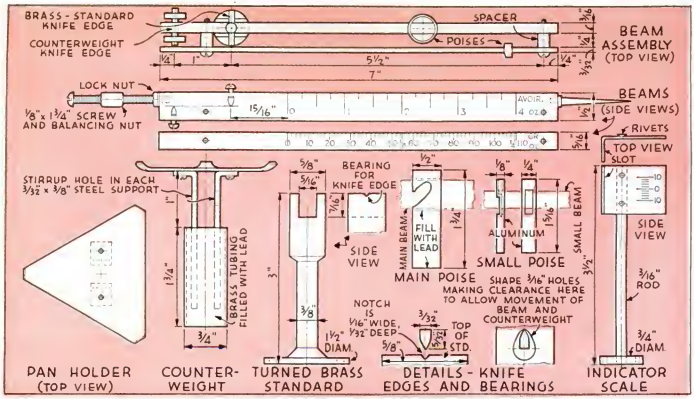
THIS scale, sensitive to 1 grain and suitable for weighing ingredients in photographic and home-laboratory formulas, can be made from bits of scrap. Its 4-oz. capacity is sufficient for most of the amateur's needs.

The main and supplementary beams of the scale shown were made of scraps of aluminum, but another metal or even plastic will serve.

Turn the brass standard first and fasten it to a temporary wood base until the assembling, testing, and calibrating are completed. Notch the bearings in the top for the knife edge with a file and finish with a scraping cut with a sharp knife. Strive to get the notches as straight and smooth as possible, for upon this the sensitivity of the scale depends.

The knife edges can be ground from a piece of tool steel, or the tang of a file can be hammered to approximate shape, hardened, ground, and then finished on an oilstone. A 2" tang will make the two knife edges with a piece to spare. Adjust them so that they are parallel to each other and at right angles to the beam.

The poise for the main beam is a piece of brass tubing filled to the slot with molten lead. This leaves some lead to be drilled out to bring the weight to exactly 1 oz. The poise for the small beam should weigh



27 11/32 grains, or 1/16 oz. Make it a little oversize of light metal so that it also can be drilled from the bottom to the exact weight. The counterweight is a piece of brass tubing filled with molten lead after the stirrups have been inserted. A pan 4" in diameter and ½" deep can be cut off the bottom of a 10-cent plastic bowl.

In testing and calibrating the scale, it is necessary to have a ¼-oz. and a 1-oz. weight. Assemble the scale in a level position with the pan in place, and set both poises at zero, marked in pencil on the beams. Drill lead out of the bottom of the counterweight cautiously, testing from time to time, until an exact balance is obtained as shown by the indicator at the end of the beam. Now place a 1-oz. weight in the pan and move the large poise out on the beam until it balances. The distance the poise has been moved should be just 1".

The small beam is tested with a ¼-oz. weight in the pan, and the distance the poise is moved to balance the scale should be just 4". The zero marks on the two beams are directly in line. Since the small beam is graduated in 2-grain divisions, and there are 109.375 grains in ¼-oz. avoirdupois, the 110-grain division will be about 1/64" beyond the ¼-oz. division.

Check the scale several times; then mark all the divisions in pencil. Permanent marks are made with a small, sharp chisel, and figures are stamped with dies. A little carbon black will make them readable. Minor variations can be adjusted for by turning the balancing nut to right or left.

If it is desired to calibrate the scale in metric units instead of avoirdupois, use a newly minted nickel, which weighs 5 grams. For weight measurements by grains, use a newly minted cent, which weighs 48 grains. Paper clips may be balanced with a cent, for instance, and counted for use in subdividing the 48-grain measurement.

Fasten the finished scale to the bottom of a box as shown, where it will be ready for use when the pan is placed in position.

TWO-PART JARS (above) in which developers are sold form useful containers for photographic solutions that must be used together, such as hypo and ferrocyanide reducer. The upper compartment will hold 2 oz. of potassium ferrocyanide solution, and the lower one 6 oz. of ordinary hypo. The amber glass of the container protects the solutions from harmful light action.—JOHN K. KARLOVIC.

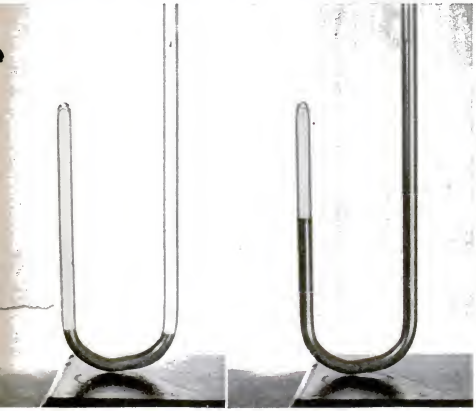
A WINDING FORM for the cord of a home-movie projector, shown below, helps prevent tangling and accidental disconnection of the plug when the machine is in use.

The form is 2½" by 12" and can be cut from a scrap of ¼ plywood. Saw a notch near one end to receive the toggle switch and connecting plug. Cut a slot along the same side so that the cord may be taped securely to the winding form as shown in the photograph.

When the projector is not in use, the plug is disconnected and the cord wound on the form inside the notches at both ends. Thus coiled, it is easy to carry.—R. WOODBURY.

CARBON DRAWING PENCILS serve well for spotting glossy prints. The point of the pencil is kept just moist with the tongue or, if much spotting is to be done, on a damp cloth. A special advantage is that spotting done with such a pencil is not affected by repeated ferrotyping. Keep the pencil well sharpened.—WILLIAM SWALLOW.

home EXPERIMENTS SHOW HOW GASES BEHAVE



BOYLE'S LAW, which states that the volume of a given quantity of gas is inversely proportional to the pressure upon it, can be demonstrated with a 40" long glass tube bent into a J-shape with the short leg about 6" long. Seal the tip of this leg. Support the tube vertically and pour just enough mercury in it to fill the bottom and rise equally in both legs as at the far left. The air in the short leg is now at normal atmospheric pressure. Pour more mercury into the tube until it stands at a height of about 30", as in the second photo. The air in the short tube is now subjected to the pressure of an extra atmosphere produced by the weight of the mercury. Compare the height of this column of air to that in the first experiment. You will find that it is only half as tall.

CARTESIAN DIVER. Fill a test tube with just enough water so that it will barely float bottom up in a cylinder or vase filled nearly to the top with water. If you seal the top of the cylinder with the palm of your hand and press down strongly, the test tube will sink. Relax your pressure, and the test tube will rise. The explanation is simple. By compressing the air above the water you transmit the pressure through the entire body of water, which in turn compresses the air in the test tube, reducing its buoyancy.

A MODEL GASWORKS TANK will demonstrate how the big ones that supply your kitchen range store gas under pressure. Punch a hole in the top of a tin can having no bottom and seal in a glass tube drawn to a jet. Into the side of a slightly larger can seal another tube bent as shown below. Attach this with a hose to the jet of a stove burner, fit on a pinch clamp, and fill the can with water. Insert the smaller can, which will sink as air escapes through the jet. When it has sunk, turn on the gas, which will lift the can. Turn off the gas and let the can sink again. Repeat until all the air is expelled; then fill the can with gas, shut off the supply, and light the gas issuing from the jet. It will burn at almost undiminished pressure until the can is empty.

ALL GASES shrink evenly when pressure on them is increased, and they expand evenly when, at a given pressure, their temperature is raised. This law is easily demonstrated. Seal one end of a narrow, 6" long glass tube; then drop mercury into the tube so that a plug is formed about halfway down. Stand the tube in a tumbler of cracked ice. When the mercury has descended as far as it will, remove the tube and mark the place with thread. Suspend the tube in the steam of a flask of boiling water. When the mercury stops rising, mark this place with thread. Measure the distance between the threads. The distance the air has expanded from 0 deg. C. to 100 deg. C. is 100/273 of its original length. For each degree, the expansion is 1/273 of the volume at 0 deg. C.

WHAT MAKES A SIPHON WORK? Two glasses are half filled with water and connected with rubber tubing full of water as shown below. Raise one glass so that the water in it is above the level in the other glass, and water will start flowing through the siphon and keep on flowing until it is again level in both glasses. The explanation for this is shown in the drawing. The upward pressure on the water in the tube at *A* is equal to atmospheric pressure (as shown by the arrow) less the weight of the water column *AB*, while the upward pressure at *D* is equal to the atmospheric pressure less the weight of the longer column *DC*. The siphon flows toward the lesser pressure until both columns are the same height.

THE SIPHON AND AIR PRESSURE. Join two small bottles, one of which is partly filled with colored water, with a bent glass tube. The siphon arm which goes into the water-filled bottle is first passed through a cork which seals the bottle. Place the apparatus in a jar which can be tightly closed. If you suck strongly on a glass tube sealed in the cover of the jar, water from the sealed bottle rises in the siphon tube and pours into the open bottle. Let air into the jar, and the water returns to the sealed bottle.

You can make this vital element in your home lab with the gas-collecting apparatus shown above

Oxygen

MAINSTAY OF LIFE

Home Experiments with This Vital Element Help Explain How Fire and Corrosion Act

By KENNETH M. SWEZEY

DO YOU know that iron and steel will burn; that the reaction of cold chemicals may produce fire; that the rusting of iron produces as much heat as the actual burning of the metal? Can you explain the mystery of spontaneous combustion? These are just a few of the facts that can be demonstrated by experiments with oxygen, the most widely distributed and abundant of all the elements.

Where can you find oxygen? It might be easier to list the places and substances where you cannot! Look in the mirror, and behold there a creature made up of 65 percent of this gas by weight! The waters of the sea and the water you drink are nearly 89 percent oxygen. Oxygen makes up about 21 percent of the air you breathe. Oxygen in the earth's crust weighs nearly as much as all the other 91 elements put together—including iron, lead, copper, and all the metallic elements.

Despite its abundance, oxygen was not discovered until a year before the Revolutionary War. Recall that oxygen is a gas without color, taste, or odor, and you can understand how it kept its identity a secret for so long.

Priestley, an English clergyman, made the discovery. He placed some red mercuric oxide on a column of mercury in a glass tube

similar to a barometer tube and heated the oxide by focusing the sun's rays on it. The column of mercury was pushed down, showing that a gas had apparently been produced. Priestley thrust a glowing splinter into the gas and found that the splinter burst into flames. Breathing some of the gas himself, the experimenter felt invigorated. A new gas had been found, which was called oxygen by the famous French chemist Lavoisier, who also showed that the gas could be made to combine with other substances.

Today, huge quantities of oxygen are made by the electrolysis of water, and by the fractional distillation of liquid air. When an electric current is passed through water, its molecules are broken into atoms of oxygen and hydrogen, which may then be collected separately. Since the boiling point of nitrogen is lower than the boiling point of oxygen, nitrogen evaporates first when liquid air is allowed to boil. When the nitrogen has all boiled away, oxygen alone remains.

In the home laboratory, oxygen may be made easily by heating a mixture of potassium chlorate or potassium perchlorate with powdered manganese dioxide. Perchlorate, if obtainable, is preferable to ordinary chlorate, as it is a more stable chemical and its release of oxygen is more easily controlled.

Mix together—without grinding—a few grams of the potassium perchlorate with about a third as much manganese dioxide. Place this in a heat-resistant test tube and clamp the tube almost horizontally on a support, as shown in the photograph on page HW 432.

As oxygen dissolves only slightly in water, the gas may be easily collected in a pneumatic trough. Part of a tin can, with a hole punched in the top and a slot cut in the side, will serve as a support for the inverted bottle in which the gas is to be collected. Bent glass tubing, connected by rubber tubing, leads the oxygen under the water in the trough into the mouth of the collecting bottle. The latter should be filled with water. A square of cardboard or glass is held over the top until the bottle is placed on the support with its mouth under the water. As oxygen is generated, it will slowly bubble up into the bottle, gradually replacing the water in the latter.

Heat the test tube gently with an alcohol lamp or Bunsen burner turned low, moving it along the tube to heat the latter evenly. Then increase the heating until gas commences to bubble from the delivery tube. The first bubbles may be allowed to escape, as these are air being driven from the tube. The following ones should be directed to bubble up into the collecting jar. The flow of oxygen can be regulated by controlling the heat.

When the jar is full, slip the cardboard or glass plate under it again and turn the jar upright. Keep the plate in place to prevent the oxygen from diffusing into the air. Before withdrawing the flame from the test tube, be sure to remove the stopper from the tube; otherwise water will be sucked up from the trough and will crack the hot test tube.

Many substances which burn feebly or not

At left below, a small piece of steel wool which has been ignited glows at red heat in ordinary air. When placed in a jar of pure oxygen, however, as at the right, it at once bursts into bright flame. The presence of oxygen increases the rate of combustion to such an extent that an intense heat results

at all in ordinary air will burn brilliantly in the oxygen you have collected. Thrust a glowing splinter of wood into it, and the splinter will burst into bright white flame with almost explosive suddenness. Twist a short length of iron wire around a small wad of fine steel wool and ignite the steel wool in your Bunsen flame. It will merely glow red. Thrust it quickly into your oxygen tank, however, and it bursts into brilliant flame.

When oxygen combines with other substances so rapidly that the heat of this combination produces flame, we call the reaction combustion. But *all* oxidation produces heat, whether the heat is apparent or not. The rusting of iron or steel, for instance, produces as much heat as the burning of the same metal. This form of oxidation is so slow, however, that the heat is dissipated as fast as it is generated.

Steel wool, a few drops of dilute acetic acid, and an ordinary thermometer can be used to prove that oxidation does actually produce heat

A simple experiment will prove that rusting produces a rise in temperature. Wrap the bulb of a thermometer with fine steel wool; then moisten the wad of wool with some dilute acetic acid, which will act as a catalyst to speed up the rusting of the metal. For best results, the acid should be at room temperature, and the moist steel wool should be protected from drafts. Rust will quickly appear, and as it does, the mercury in the thermometer will slowly rise.

Spontaneous combustion is the result of the accumulation of heat due to slow oxidation of inflammable materials under conditions where this heat cannot be dissipated. The linseed oil in paints, for example, dries into a tough film because of the combination of the oil with oxygen in the air. Heat is generated, but when the oil is spread over a surface, this heat vanishes as fast as it is produced. Throw rags soaked in linseed oil into a pile, however, and you bottle up the heat of oxidation to such an extent that you produce a dangerous fire hazard.

To demonstrate the heat of oxidation of linseed oil, insulate a jar by placing it in a box stuffed with crumpled paper, and place in the jar a rag or bit of cotton waste wet with this oil. Place a thermometer in the midst of the rag, and observe it periodically. The temperature climbs steadily. If left long enough, the rag would probably catch fire.

Rapid oxidation resulting in combustion may be produced by the reaction of cold chemicals. Place a few grains of sodium peroxide on some absorbent cotton. Add a drop or two of warm water. Almost instantly the cotton will burst into flames.

Even the familiar hydrogen peroxide may be made to produce oxygen. Heat, alkalies, and even dirt or powdered glass will cause it to decompose. Powdered manganese dioxide dropped into the liquid will cause the gas to come off rapidly.

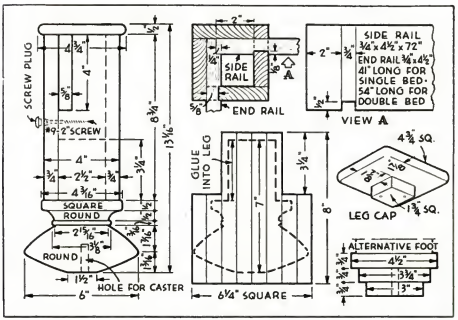
Place a little sodium peroxide on a wad of cotton and drop some warm water on it as in the first and second photos below. In an instant the cotton flares up as at the right. Reaction between the sodium peroxide and the water oxidizes the cotton so rapidly that it bursts into flame almost immediately

Except for the bed rails, which should be sound, straight stock, scrap can be used to advantage

Collapsible Bed Has No Metal Parts

THIS bed is the perfect answer to your extra bed problem. The scarcity of materials is no hindrance to constructing it because the only metal used is in the casters. The chassis is completely separate from any other part of the bed, and can be used with any type of spring and mattress. A further advantage is that the bed can be taken apart for storage or shipment, and easily reassembled.

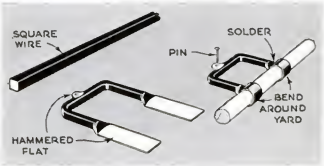
The standard height for beds is specified in the drawings, but this can be altered to suit personal needs. Simply measure the spring and mattress and make the legs as high as desired. If made of poplar and oak, with turned feet as shown in the drawings, the rails and legs may be painted bone white, and the caps and turned feet stained a warm brown.—J. I. SOWERS.



This attractive bed base can be built to fit any type of spring regardless of size. Notice end rails have rabbet and dado but side rails dado only

Microscope Specimens Mounted with Cardboard and Tape

AN EASY way to mount dry microscope specimens permanently is to place each in a cardboard cell secured to a slide with ordinary adhesive tape. The cell must be of the same thickness or slightly thicker than the specimen so that the cover glass will not crush it, and it should be of the same area as the cover glass. An opening may be made in it with a paper punch or cut square with a sharp knife. When specimen and cell are in place, cover with the glass and fasten all to the slide with strips of common adhesive tape. A label may be attached at one end for identification. The tape can be varnished for permanence.—H. F. WHITTAKER.



Wire Trusses for Model Yards

TRUSSES to support the lower yards of ship models may be easily made from square copper wire as shown in the drawing above. Hammer the ends of the wire flat, and flatten the middle also so that it can be drilled for an escutcheon pin. The two ends are then bent around the yard as shown and soldered in place. This type of truss will be found entirely suitable for most ship models.—S. P. ROBBINS.

Above is a "before and after" photo in the life of a paintbrush. The bristles were all a hardened mass, but the ones on the left side were given a thorough cleaning until they emerged soft and glossy. Compare them with the caked bristles on the right side

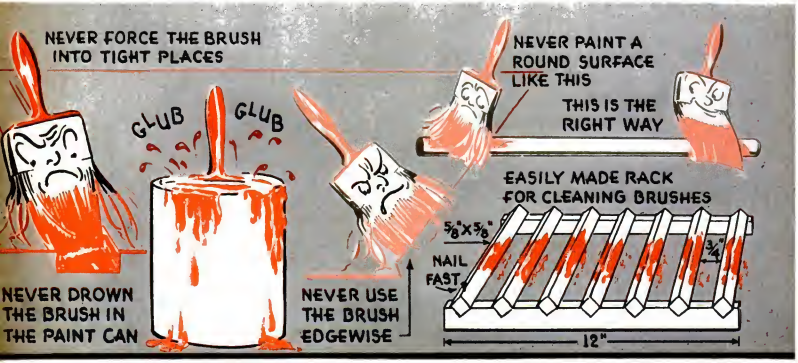
How to

EVEN THOSE WITH BADLY CAKED BRISTLES CAN BE SOFTENED, CLEANED, AND RESHAPED SO AS TO GIVE GOOD SERVICE ONCE MORE.

By ALBERT Q. MAISEL

DON'T throw away that old paintbrush. It may be as hard as a board, bristles may have dried askew, some of them may be missing; but the chances are that there is plenty of life left in the old brush yet. It may need only a cleaning to get out the caked paint and to restore flexibility. If it happens to be a brush made of Chinese hog bristles, which are now scarce, it's worth its weight in gold. Just so long as the bristles are firm in their base, any old brush can be reclaimed.

The first step is to soften the hardened heel in a solvent. Never try to break loose even part of a caked heel while the brush is dry, for you will break valuable bristles in the attempt. Benzine can be used as a solvent, or any good commercial paintbrush cleaner. Use alcohol for old shellac brushes. Put just enough of



Put Your Old Paintbrushes Back to Work

the fluid in a glass container to cover the bristles but not the setting and ferrule.

Soak for 10 minutes; then knead the brush in water to wash out the loosened paint, repeating both steps until the heel is soft. Most of the paint will come out in the water, and the remaining solvent can be strained through a cloth and stored away for future use.

Now spread the bristles with your fingers and sift fine, dry, hardwood sawdust down into the deepest parts of the brush. Then, under a stream of water in a sink, work the brush back and forth over a washboard or a rack made as shown in the drawing. Five to 10 minutes of this, with the addition of more sawdust as required, will clean the worst caked heel. The sawdust picks up particles of paint and carries them away in the water. Any flakes of dried paint remaining can be removed by working the paintbrush across a stiff fiber scrubbing brush held bristles up in a vise or nailed to a bench top. Be sure the paintbrush bristles point backward as you draw them over the fiber brush.

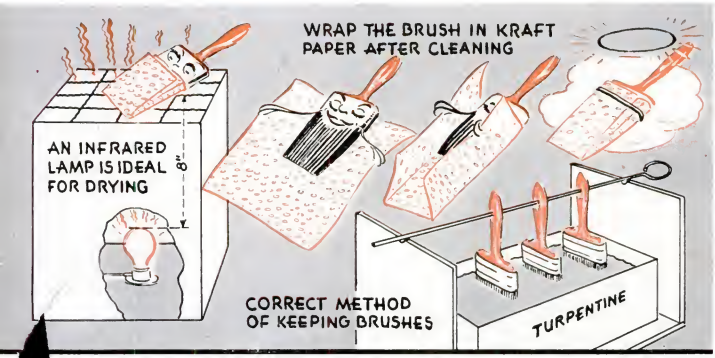
The soaking-wet, soft bristles will stick out in all directions. Comb them straight with a fine comb and remove any loosened ones by grasping them between the blade of a paring knife and the thumb.

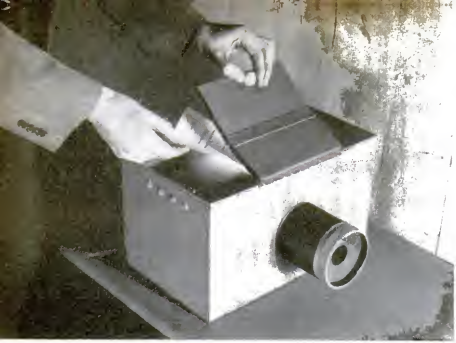
Next, wrap the brush in stiff kraft paper to preserve the fine chisel edge while it is being dried. Perforate the paper for better ventilation and fold it as shown in the drawings. Drying can be done in the hot sun, or over an infrared lamp or an ordinary bulb placed in a box as shown below. A brush of average size will require 45 minutes to one hour to dry, and it should be turned over every 10 minutes during this time. This insures even drying and prevents curling of the bristles.

When thoroughly dry, a brush may need a final combing, and the bristles may be trimmed if they have worn very unevenly. This may be done with a sharp knife or a razor blade. Be careful to cut off no more than absolutely necessary.

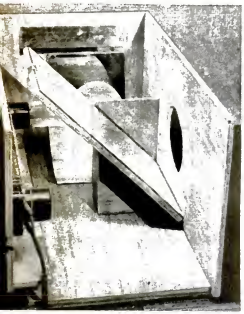
Now take a look at the handle, which may be spliced if it is damaged or broken. If the ferrule holding the bristle base to it is loose, it may be tightened. A couple of brads through it into the wood may do the trick, or on some types a wooden wedge may be driven in to make a tight fit.

Take care of the brush once you have it back in shape. Never use force to daub its end into corners, and don't use a brush edgewise. Dip the bristles not more than halfway into the paint. Put the first two coats on rough surfaces with a worn brush, rather than with a new one. Avoid kerosene; it won't evaporate, doesn't mix with paint, and may damage the setting. When left in turpentine, a brush should be suspended so that it won't rest on the bristles. A rack like the one shown below is good.

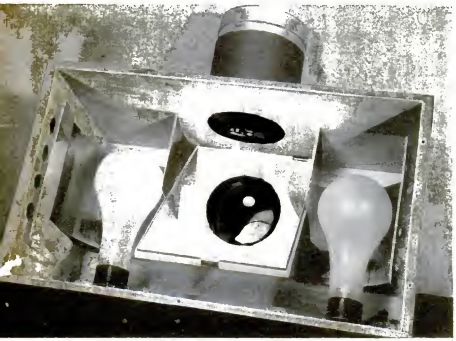




Laid face down on a glass in the top of this box, a picture may be projected onto a screen. The hinged lid holds it flat



Set at an angle of 45 deg., the mirror reflects the image of the picture above it through the tube (shown above, right, before assembly) to the lens, which in turn throws it onto the screen. Below, a view of the projector with the top off



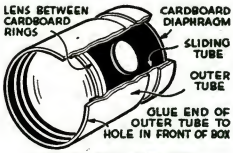
WITH an opaque-picture projector, or post-card projector, you can throw enlarged images of drawings, photographs, and magazine clippings on a screen in full color. Besides providing entertainment, such a device is useful in instructing groups of people, copying art work, and lettering.

Dimensions of the box can vary, with the possible exception of the height, which is 8″ and correct for a lens of about 9″ focal length. For a shorter focal length, the height should be reduced. The distance from lens to mirror to picture must be approximately equal to the focal length of the lens.

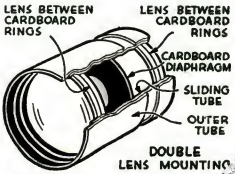
The mirror is mounted on a piece of ½″ plywood which, in turn, is fastened to a wooden block the upper surface of which is at a 45-deg. angle to the front of the box. A single screw holds the block to the bottom of the box, thus permitting the mirror to be swung slightly to line up the image. Once the mirror is adjusted, the screw is tightened.

The width of the box from front to back may have to be altered, according to the sockets used, to bring the lamp filaments approximately into line with the center of the picture to be projected.

Air space around the lamps protects the wood from heat. An



SINGLE LENS MOUNTING



DOUBLE LENS MOUNTING

opening along the bottom of the back and holes in each end provide ventilation. Wire the sockets in parallel, run a cord out through the ventilating slot, and install a through-cord switch a foot or so from the box. The top of the box has a rectangular opening, rabbeted or provided with strips to receive the glass. The glass merely lies in the recess and may be lifted out for cleaning or changing a lamp. Metal hinges or leather strips are used on the hinged lid.

The lens is the most important part of the projector, for upon its performance depends the sharpness of the image. An anastigmat of f/4.5 speed or greater and a focal length of 8" or more is best. Such a lens may be taken from a view camera or from another projector. An ordinary reading glass 2" to 4" in diameter and with a focal length of about 8" may be used, but image sharpness will be improved with a multiple lens arrangement.

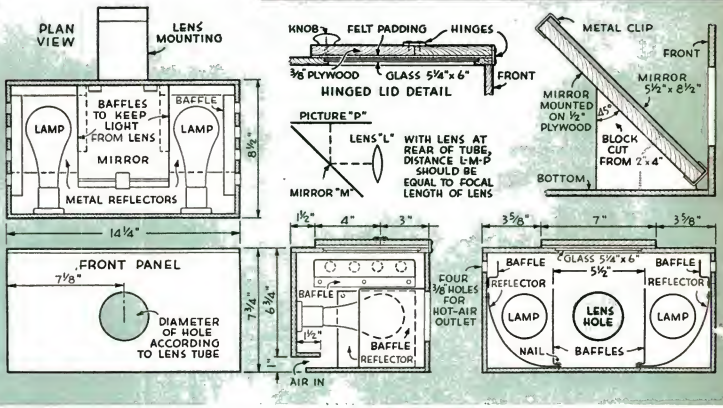
Mount the lens at the end of the tube near the box, and 3" or so in front of it mount a diaphragm made by cutting a round hole in a cardboard disk. Experiment with hole sizes to determine the best diameter. The smaller the hole, the sharper the image, but illumination decreases as the diameter of the aperture becomes smaller. There is, fortunately, a happy medium. Paint the diaphragm flat black on both surfaces and the edge of the hole; then cement it to the lens tube.

Two lenses of the reading-glass type, each having a focal length of about 18", can be combined into a two-lens projection objective, as shown in one sketch. Experimenting will reveal the exact spacing of lens elements. To determine focal length, hold a lens so it throws a sharp image of a distant object on a sheet of paper and measure the distance from lens to paper. The lens mount illustrated was made from a cardboard tube and lid. The lid, with its end cut away, became the outside of the lens mount, and a piece of the tube made the movable inside section.

Cut black paper to mask the sharp section of a projected image and paste it on the glass in the top of the box. Cover the underside of the lid with black cloth to keep light from leaking around the edges.

PICTURE PROJECTOR

GIVES BIG, FULL-COLOR IMAGES FOR ENTERTAINMENT, INSTRUCTION, OR COPYING OF DESIGNS, ART WORK, AND LETTERING ALPHABETS



Harnessing Electrons

WHAT HAPPENS IN THE DIODE—SIMPLEST OF FIRST STEPS IN ELECTRONICS

By JOHN W. CAMPBELL, JR.

IT IS a triumph when the electrical engineer produces a device that can break a circuit in 1/100 second, but the electronics engineer can turn a current on and off 500,000,000 times a second. The electrical engineer's control of electricity depends upon relatively crude, slow-acting mechanisms such as rheostats, fuses, circuit breakers, and solenoids; the electronics engineer controls the electronic flow by means of other electrons forced to work in the confines of electron tubes.

These tubes are used for detecting radio waves, amplifying currents, generating alternating currents of practically any frequency, and rectifying alternating current to direct current. Applied in sound motion pictures in the form of highly sensitive photoelectric cells, they convert the varying light density of a film track into sound. Special electron tubes react to the light of a star a billion billion miles away, probe for a bullet, and control big guns with superhuman accuracy.

We know (Fig. 1) that electrons can be repelled by or attracted to a body by putting an electric charge on that body—that is, by crowding other electrons onto it or by robbing it of electrons. By applying this principle inside vacuum tubes, we gain control of these invisible miracle workers. The simplest vacuum tube consists of an electron-emitting electrode, called the *cathode,* and a target for the electrons, called the *plate.* Triodes (three elements), tetrodes (four elements), and so on are only diodes to which additional control elements have been added.

Since the current that will pass through the tube consists of the electrons emitted by the cathode, it will be limited by the number of electrons we can free from the metal of which the cathode is made. The atoms of the metal exchange outer electrons freely; these electrons may wander at will among the atoms and, if extra electrons are crowded upon one end of a wire by connection to a battery or generator, an equal number of atomic electrons promptly appears at the other end. But unless outside force is applied, the electrons cannot escape from the wire. This is shown in Fig. 2.

Our problem is to supply the electrons with sufficient extra energy to enable them to break loose from the atoms and escape from the metal altogether. This we can do by heating the metal, since heat causes motion of atoms and some of this motion is imparted to the electrons. How much heat is necessary depends upon the nature of the metal or alloy.

Radiant energy such as light, X rays, or cosmic rays will also free electrons by imparting motion to them. Light striking the sensitive element of your photoelectric meter knocks out electrons that flow through a sensitive galvanometer and move a needle to indicate what exposure you must give a scene in photographing it. Cosmic rays, present everywhere on the earth's surface, are always freeing electrons from matter. A single electron striking a metal target at high speed may blast out a number of other electrons before it finally comes to rest. This method is used in Zworykin's electron multiplier, a special multiple diode that can amplify currents more than a billion times.

When a single atom of radium explodes, it shoots out electrons at tremendous speed, as well as high-power X rays called gamma rays. Both of these knock electrons out of any adjacent atoms, and with such violence that these electrons knock out others in turn, until hundreds or even thousands are freed (Fig. 3).

Thermionic emission—the freeing of electrons by heat—is the simplest method and the one most frequently used. Cathodes in modern tubes are coated with certain alkaline-earth oxides that release electrons at moderate temperatures. The

In this X-ray tube, 400,000 volts are required to drive electrons from the filament across a gap to the target

in Glass

ALL VACUUM TUBES

cathode is usually heated by a filament similar to that in a lamp bulb (Fig. 4). In early tubes and some modern types, the filament itself is the electron-emitting body.

If to the plate of the tube in Fig. 4 we apply a positive charge by connecting it to the positive (electron-deficient) side of a battery or generator, electrons emitted from the cathode will be drawn to it and will constitute a current in any outside circuit we may arrange. But if the cathode is positively charged, electrons driven out by the thermionic effect will promptly be drawn back, and no current will flow.

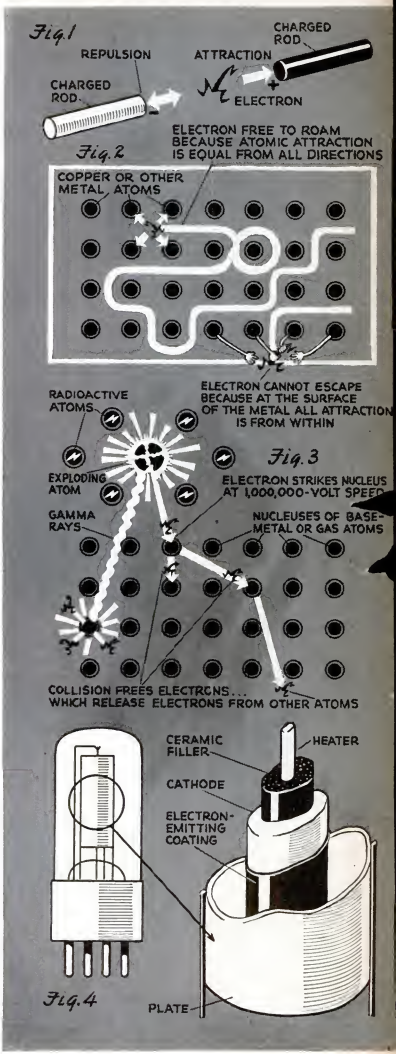
Here the first characteristic of the vacuum tube appears—it will pass current in one direction only. If alternating current is applied to it, the tube will pass current only on that part of each cycle on which the cathode is negative. The diode tube is therefore first of all a *rectifier*.

This is generally useful; a characteristic not so useful is voltage drop. An electronic tube has terrific internal resistance. After electrons have been freed from the cathode by thermionic or other action, they tend to form an invisible cloud in the space surrounding the cathode. This "space charge" acts to repel the electrons driven out by thermionic action, sending them back into the cathode as fast as they emerge.

A space charge normally forms much closer to the cathode than to the plate, and a very much greater voltage is needed on the plate to overcome the space-charge effect because of the inverse-square law effects in electric repulsion. Thus a space charge of only two volts at .01" from the cathode would block electrons attracted by a plate .1" away charged to 150 volts! It would take more than 200 volts on the plate to pull electrons through that two-volt space charge.

In high-vacuum rectifier tubes designed to handle fairly heavy loads, the plate is put extremely close to the cathode—frequently less than .01" separates the two. The un-

Photograph courtesy of General Electric Co.



avoidable gap reduces it but, in spite of this, the space charge resists the passage of electrons from the cathode until they enter its own region. Once they get this far, it pushes them onward with equal force, which now reinforces the pull of the plate charge.

It would seem that a sufficiently high plate charge would drive as much current as we might wish through the tube, but the accelerating action of the space charge just mentioned, plus such a high plate potential, would drive electrons to hit the plate with such violence that their bombardment would heat it. When hot enough, the plate would begin to emit electrons itself, rectification would cease, excessive current would flow, and the tube would be ruined.

There is, however, one type of tube purposely designed as an inefficient rectifier with the plate several inches or, in large tubes, even a foot or so from the cathode. With such a setup, it takes not hundreds of volts, but hundreds of thousands, to drive electrons through the space-charge blockage, and they hit the plate at a speed as high as 175,000 *miles per second.* Deceleration causes the electrons to radiate extremely short-wave-length electromagnetic energy—called "hard" radiation or X rays.

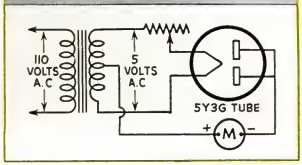
In a diode having an atmosphere of low-pressure mercury vapor, argon, or neon, electrons flowing from the cathode to the plate are almost certain to bump into a gas atom on the way and knock off a secondary electron. The gas atom, now a positive ion, is attracted toward the cathode, while the dislodged electron heads for the plate. Near the cathode the gas ion picks up another electron and becomes neutral; but it promptly undergoes another collision, and is again a positive ion.

Under such conditions, there will always be many positive ions near the cathode, and their presence will neutralize the negative space charge. The result is that the voltage drop of the gas-filled tube will be very much lower than that of a vacuum tube, actually only a few volts, regardless of the current.

The cathode need supply only a few electrons. Once they start knocking electrons from mercury-vapor atoms, more and more are released until finally a billion or a thousand billion electrons arrive at the plate.

The mercury-vapor rectifier, alone of the electronic devices, is adaptable for heavy duty. It can handle tens of thousands of amperes as readily as it handles milliamperes and can operate at tens of thousands of volts.

Simple Diode Hookup Demonstrates Effect of Space Charge



IF YOU have or can borrow a milliammeter, you can demonstrate with any type of radio tube how electron emission and space charge increase with the temperature of the cathode. Connect the filament or heater to transformer taps of the proper voltage or to the line through a resistor of the correct value, inserting an adjustable rheostat to control the filament temperature and thus the number of electrons emitted.

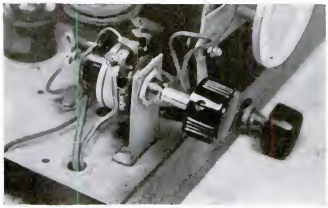
The milliammeter is connected to the cathode and plate of a heated-cathode tube such as a 117Z6-GT. With a coated-filament tube, connect the meter to the plate and to the center tap of the transformer.

Since no plate-current supply is provided, the cathode, which is losing electrons, will take on a positive charge. The cloud of electrons within the tube gives the plate a negative potential. The more electrons emitted, the greater these opposite charges become. Since the meter is connected across the points of opposite potential, a current of several milliamperes will flow, and this will vary as the number of electrons emitted increases with the temperature of the cathode.

If a high-resistance voltmeter is used instead, the voltage of the space charge can be measured. It is usually one to five volts.

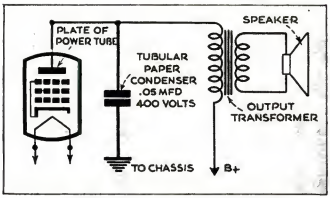
Servicing Your Radio

TONE, volume, and selectivity of midget A.C.-D.C. T.R.F. receivers can be improved by making a few minor changes. Tinny sounds often can be corrected to a certain degree, and a noisy volume control may be replaced with a more suitable one. Old-style glass-bulb tubes will serve for metal ballast tubes that burn out, while new-type coils will greatly improve range and selectivity.



SQUEAKS AND HOWLS or loss of volume when the volume-control knob is moved indicates a faulty control. About 90 percent of the midget A.C.-D.C. T.R.F. sets use a volume control in the form of a metal-encased variable carbon resistor combined with a switch. Replacing this with a 25,000-ohm control will prove satisfactory in most cases even though the one originally contained in the set may have had a resistance of anywhere from 15,000 to as high as 35,000 ohms.

METAL BALLAST TUBES can easily be replaced when they burn out by those having glass bulbs, and the latter will even be found to have some advantage, especially in the matter of heat dissipation. Be sure that the tubes have the same or equivalent code numbers. In a designation such as K55C, the first letter indicates the type of pilot bulb to use (K—brown bead, No. 40; L—blue bead, No. 46; M—white bead, No. 50 or 51). The number is the voltage drop across the tube, and the last letter gives the key to the tube wiring.



TINNY SOUNDS common in some small A.C.-D.C. receivers may be the result of the high notes being accentuated too much. This annoying condition can be corrected to some extent by connecting a .05-mfd. paper tubular condenser of 400 volts working voltage between the plate of the power tube and the chassis. If the set has a condenser in this position, it probably has a lower capacity than .05 mfd. On a 43 power tube, the plate connection is at pin No. 2; on a 25L6, it is at pin No. 3.

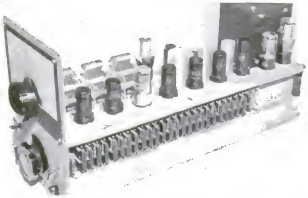
SELECTIVITY AND RANGE can be improved greatly by replacing the old R.F. coils with newer types. The best results will be obtained by substituting iron-core coils, but even air-core, litz-wound coils will make a noticeable difference in the performance. Small T.R.F. sets usually are equipped with coils that are not wound with litz wire, are not so well insulated, and are not sealed against moisture, and therefore do not have as high a *Q* or amplification factor as the newer coils. Either shielded or unshielded coils may be used in making the replacements.

radio ideas

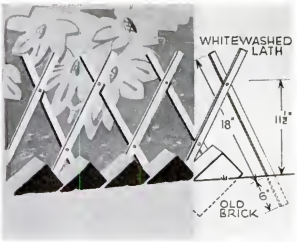
RADIO AMATEURS, no longer able to indulge in their hobby, may find a place for their energy in the War Emergency Radio Service, a new development in radio communications for civilian defense. Junked radio sets and parts, salvaged from attics and cellars, are being rebuilt by amateurs and professionals into two-way stations and operated for the common good. This means of communication bids to set our country ahead of all others in having an independent, foolproof auxiliary that will function regardless of the loss or crippling of all other forms of contact across distances. In the photo at left above volunteers are making sets out of junked parts, while in the other operators stand by at a WERS station. These are OCD photos from the Office of War Information.

THIS THROAT MICROPHONE strapped around the neck over the larynx picks up words spoken by the wearer and amplifies them in combination with any standard equipment supplied our armed forces in the air, on land and sea, and under water. The device will be particularly useful in planes and in tanks because there is no need to shout, and the mouth is left free of all restrictions which hamper expression, either by voice or muscular reaction.

FLAPS ON A NEW RECORD ALBUM prevent accidental dropping of records when the album is unintentionally held upside down. Placed at the top of all compartments, they also tend to keep dust from sifting into the envelopes and to guard against slipping records between compartments. Both 10" and 12" albums are available in this style.



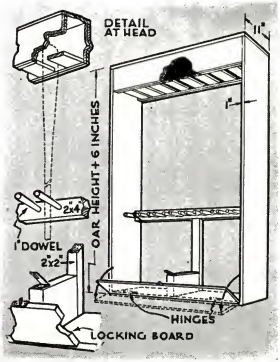
COMMUNICATION RECEIVERS are now being built in separate units, each one on its own specially shaped chassis with fixed resistors and condensers conveniently placed on the outside for rapid servicing, as shown in the 12-tube set above.



A PICTURESQUE FENCE that will set off a lawn or flower plot to advantage can be made at low cost from ordinary laths. About 7″ at the bottom of the laths should be creosoted by standing the bundle in a bucket of creosote compound. Set the laths about 6″ deep in the ground, keeping those that slope in the same direction as parallel as possible. Use single nails where the pieces cross.—HI SIBLEY.

OAR RACK. Where several boats are in constant use, the care of oars is a problem that can be much simplified by the use of a rack, such as the one shown below and in the drawing. It goes far toward reducing the loss of oars and damage caused by warping and breakage, permits the oars to be kept in numbered pairs, tells at a glance how many boats are in use, is easily locked when your camp is left alone, and provides a winter storage box.

The top of the rack is entirely enclosed. Oars are inserted with the blades uppermost between partitions. The shafts fit between dowels set in the crosspiece, and the handles rest squarely on the bottom. A hinged board across the bottom can be secured with a padlock. When this is closed, none of the oars can be removed.—MILTON KLEIN.



By E. W. LEHMANN

Head of Department, Agricultural Engineering, University of Illinois

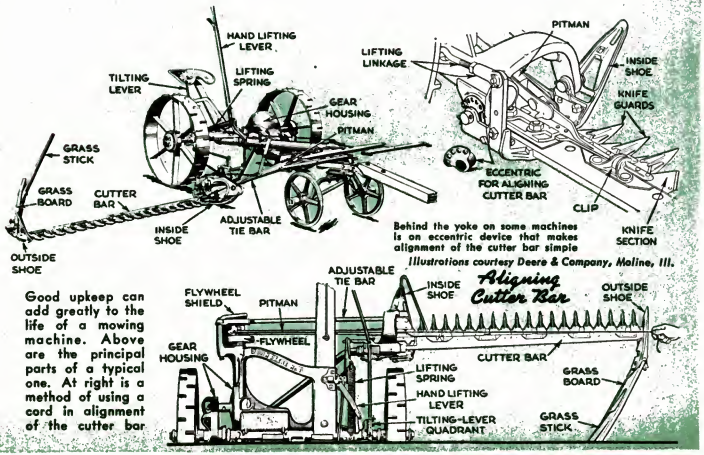
TO GET along with old machines at a time when the farm labor supply is limited makes it particularly important to avoid breakdowns in the field. Since the mower is used during the fall as well as in the early part of the summer, checking and repairing it now will not only insure its readiness for the first cutting of alfalfa next year, but make a better job of the last this fall.

Toward the end of the season is, in fact, always a good time to check machinery because the operator knows then whether there is anything wrong with it. If the mower knife is dull or poorly adjusted, it is hard to pull and takes a lot of unnecessary power, and if parts are loose or badly worn, breakdowns are likely to occur.

Check the alignment of the cutter bar—the heart of the mower. With the machine on level ground, block up the front end of the tongue about 2½′ and drop the cutter bar so the inner and outer ends rest on the ground. Tie a string to the center of the pitman bearing and hold it tight along the center line of the pitman over the knife head. Pull the cutter bar back by hand until it is in cutting position; then measure from the line of rivets on the cutter bar to the string. The outer end of a 6′ cutter bar should be about 1½″ ahead of the inner end—a lead of about ¼″ for each foot of length of the cutter bar. Alignment of the bar may be corrected by adjusting the eccentric behind the yoke as shown in one of the drawings. On some machines, it is necessary to drill out or file the old holes in the yoke casting with a rattail file and fit in oversized pins in order to take up slack caused by wear.

The register of the knife is checked by turning the pitman wheel for a complete stroke of the knife. If the knife sections do not stop in the center of the guards at each end of the stroke, the mower will clog and will not cut properly. Some mowers have a provision for adjusting the entire cutter bar in or out. On older makes it may be necessary to lengthen or shorten the pitman, which is a wooden rod with a box bushing on one end and a ball-and-socket knife-head bearing on the other. The length is changed by removing the rivets and replacing the wooden rod with a new one.

Guard alignment may be checked by moving a straightedge along the top of the guard plates after removing the knife. Note



Good upkeep can add greatly to the life of a mowing machine. Above are the principal parts of a typical one. At right is a method of using a cord in alignment of the cutter bar

those that are high and those that are low. Drive unaligned guards back into alignment by a blow with a hammer. The plates have serrated edges and, when badly worn, should be replaced. If the greater thickness of a new plate puts it above the others, it may be necessary to lower the entire guard by placing tin shims between it and the cutter bar.

A sharp knife or sickle is essential, an extra knife is desirable as a spare, and knife sections should be available at all times for replacement of those that may be damaged or broken. Check the knife bar to see that it is straight. In grinding the knife sections, maintain the same cutting angle and bevel as on new sections. To replace an old section that has worn much shorter than the others, remove the knife from the

cutter bar, and then hold the edge of the knife bar on the edge of an anvil or piece of railroad iron. Shear the rivets by striking a sharp blow on the edge of the section above each and remove them with a punch. Special riveting sets are convenient, but a good job can be done with a ball-peen hammer.

For best results, adjust the clips after the knife has been straightened and made to register. Begin with the clip next to the inside shoe and, if it is bent up, tap it lightly until it begins to tighten on the knife bar. Examine and adjust all clips in the same manner; then check to see that the knife can be moved freely by hand.

Check the pitman for end play and twist. Excessive lost motion caused by wear in the ball and socket can best be taken up by renewing the knife head and the pitman bearing. Some mower models are equipped with a knife-head correction self-adjusted to take up wear. If a badly worn crankpin in the pitman wheel causes lost motion, remove the crankshaft, saw partly through the worn crankpin, and break it off with a hammer. The small end of the crankpin can then be driven from the wheel, and a new one installed. While the crankpin is out is a good time to check the condition of the crankshaft bushings, which may need to be renewed.

For ease in operation, see that the lifting spring is at the proper tension to permit the cutter bar to float over the ground without dragging. Check also the tension of the lifting spring to permit easy raising of the cutter bar.

The chief function of the outer and inner shoes is to support the cutter bar and to keep it level. Replace badly worn parts. The proper angle of the grass board and stick is essential to good operation in cutting high grass. The spring tension on the board should be sufficiently flexible to side pressure and yet stiff enough to force the grass away.

In horse-drawn mowers the power to operate the knife is usually transmitted from the wheels by rachets and pawls. Check the pawls and the pawl springs, see that the pawl boxes are clean, and renew badly worn parts or surfaces with a file. *(CONTINUED)*

Provision is made on many machines for adjusting the meshing of drive gears by means of a nut on the end of the counter-shaft. On some the adjustment is made by means of an adjustable collar or by the use of washers. Replace worn gears and badly worn parts of the clutch mechanism.

To put the mower in the best condition for operation, check all bearings for wear. Flanged bushings can be replaced after driving out the old ones with a piece of shafting slightly smaller than the shaft.

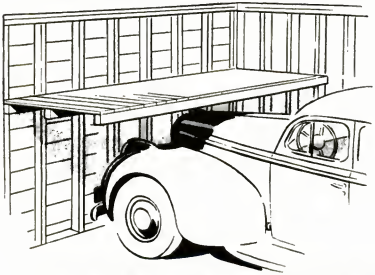
Finally, check the entire machine for loose nuts, worn bolts, broken cotter keys, and weakened or worn parts. There is always danger of breakage where lost motion is present because of loosely fitting parts, and these also impair operating efficiency.

It is generally understood that, while there may be fewer new machines available, the supply of parts will be adequate for the farmer to make his old machines do their work. Careful cleaning, adjusting, repairing, painting, and lubrication will make these old machines last several years longer. It is wise also to check them early enough to get in your order for parts that you may wish to replace during the winter months.

Handy Blackout Flashlight Made by Reversing the Reflector

ANY ordinary flashlight can be adapted at a moment's notice for blackout use. No additional parts or materials are needed for this handy trick. Remove the flashlight lens entirely. Take out, invert, and replace the reflector; then screw on the lens holder. This reduces the light aperture to the small hole that formerly accommodated the bulb, so that only a pale circle of light is emitted, which compares favorably with the illumination of elaborate and expensive blackout flashlights.—RAY JUTILA.

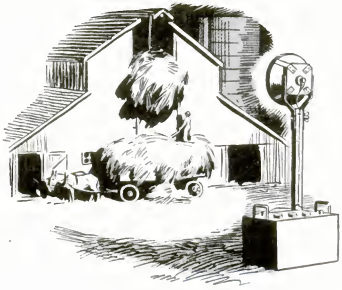
Storm Sash Are Stored on Shelf Installed at End of Garage



SPACE in the garage that would otherwise go to waste can be used for easy storage of storm sash in the summer and screens in the winter. Nail 2 by 4's across the garage from stud to stud to form a shelf above the radiator of your car at a height that will be convenient to reach. Nail on either a board floor as shown, or one of slats, which may be nailed a few inches apart to keep dust from collecting. If many sash are to be stored, cleats under the ends of the 2 by 4's will add support.—WILLIAM FREEMAN.

Sealed-Beam Headlight Unit Makes Powerful Searchlight

WHEN one beam of a sealed-beam headlight burns out, the unit can no longer be used legally on a car, but it can be made into a powerful, portable searchlight that will help greatly on a job that must be completed at night. Nail an upright to a wooden box large enough to contain the storage battery that will provide current for the light; then, on the upper end of the standard, fasten a small bracket to which the sealed-beam unit may be bolted by means of its mounting clips. Such a unit may also be mounted on a tractor or other farm machine and connected to the regular starting and ignition battery.—ROBERT MANN.



NOW YOU SEE IT... NOW YOU DON'T

The Story of Katharine B. Blodgett

CURIOUS is the word for Katharine Blodgett. And her eagerness to experiment with new ideas gives an original twist to everything she does. Now one of the outstanding scientists of her day, this twinkling-eyed Bryn Mawr graduate built up 44 *invisible* layers of barium stearate on glass—to make it so non-reflecting that you can't see it!

Though Katharine Blodgett's father had been a General Electric patent lawyer, she didn't "begin with askings" when she came into the Company. Armed with a brand-new M.S. from the University of Chicago, she began her career in the "magic" department of the Research Laboratory. After a few years of experimenting with molecules, she went on to the Mecca of all physicists, the Cavendish Laboratory at Cambridge University, England, where she was the first woman to receive a Ph.D. in physics.

Dr. Blodgett still remembers the cold English winters. The men in the class didn't suffer so much—they had learned to write with either hand, in order to alternate the hands they kept in their pockets. *She* had to sit on one hand and take notes with the other. One day she took a thermometer to class, and it registered only 40 degrees!

Knowing *why* doesn't satisfy a scientist like Dr. Blodgett. She feels deeply that she is not the master of a subject until she knows also why *not*. That's the real reason she makes popovers every Sunday morning—to find out why they aren't consistent in popping. Right now she thinks the answer may lie in the type of milk used, so she's experimenting with all kinds.

She carries her scientific attitude into the garden, too. She analyzes the soil before she plants the seeds, and this year she has a Victory garden, where she's spending most of her time outside the lab.

So screened is the Research Laboratory with war secrecy that nothing can be told right now of her work there. But it's the seeking, patient minds like Katharine Blodgett's that help to bring the peace nearer, that will make that peace *surer* once it is won. *General Electric Co., Schenectady, N. Y.*

Hear the General Electric radio programs: The "Hour of Charm" Sunday 10 p.m. EWT, NBC—"The World Today" news, weekdays 6:45 p.m. EWT, CBS.

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CASITE

CLEANS OUT MOTORS · KEEPS MOTORS CLEAN

Fort Busters

(Continued from page 53)

is slapped in place. The job is incomplete until the walls (sometimes six feet thick) are opened sufficiently to knock out the bunker crew with hand grenades. That done, the leader motions his men on to the next bunker, leaving the mopping up to assault infantry close behind.

German fixed fortifications are known to have as many as nine bunkers connected by bombproof tunnels. Usually each bunker supports at least two others with its fire, and the steel-and-concrete network remains a hazard to attacking forces until the last fort is smashed. That's the task of the demolition engineers. They must keep on smacking as long as there's as much as a pillbox in the vicinity.

The colossal size of the work before them must be understood by Americans at home as well as by our military leaders abroad. It is best shown by intelligence reports that reveal Germany to have fixed fortifications running to a depth of 50 miles, concentrated into jagged belts each several miles deep. Greatest of all Reich fortifications, the West Wall (Siegfried Line) has three such belts, staggered six to 25 miles apart. In the rear are forts with high-velocity guns usable against aircraft or ground forces.

Before the first belt is a landscape sown for 300 yards with mines and gouged with moats. Then come what our engineers call "dragon's teeth," concrete-and-steel tank obstacles five feet high set in jagged rows two to six deep. The approaches are topped with additional mines beneath a tangled morass of barbed wire. Hitler applies 15,000 mines and 100 tons of wire to each division front of 5,000 yards.

Blasting the dragon's teeth with TNT is a relatively simple job once the protecting bunkers and blockhouses have been demolished. But while these are hurling shrapnel at the attackers, it's extremely perilous. Some strategists recommend the use of smoke screens to blot the enemy's vision during assault. Smoke mortars do the trick easily, but the smoke may work to the disadvantage of the attacking force if it becomes necessary to see the objective in order to plaster embrasures with high-velocity shells.

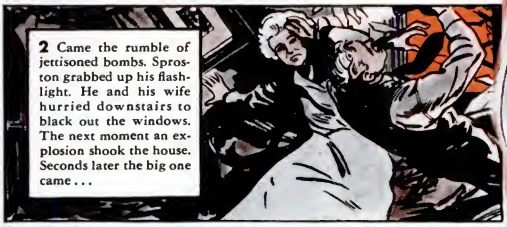
The West Wall, as tough as it may be to crack, holds a secondary place in European fortification lines that must be smashed before invasion forces attain their goal. The Nazis have built an almost incredible number of forts to bolster defense walls and

(Continued on page 204)

SECONDS LATER THE BIG ONE CAME!

A true experience of Mr. and Mrs. James Sproston, of Cheshire, during the big air blitz over England.

1 Night after night they heard the great German Heinkel bombers roaring directly overhead, Liverpool-bound and loaded with bombs. Then one night Jerry was late. Feeling safe, the elderly English couple prepared to retire. Suddenly the sirens began to shriek . . .



2 Came the rumble of jettisoned bombs. Sproston grabbed up his flashlight. He and his wife hurried downstairs to black out the windows. The next moment an explosion shook the house. Seconds later the big one came . . .

3 . . . Half demolished the house and threw its stunned occupants violently to the floor...Some time after, two passing air wardens saw a light shining out of the wreckage. It was the beam from Sproston's faithful flashlight—a beam that directed the rescue of two more victims of the Luftwaffe's ruthlessness.

SPARE YOUR FLASHLIGHT BATTERIES!

For your own emergency protection (witness the Sproston's experience) as well as to conserve critical war materials, use your flashlight normally as little as possible. Make a habit of flashing it *intermittently*, not *continuously*. Also:

If you can't get "Eveready" flashlight batteries, don't blame your dealer. The Army, Navy and Lend-Lease get first call on the supply, and few are left for civilians.

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THE "Pals" THEY LEFT BEHIND

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Letters continue to pour in from men in the armed services telling how they miss the Harley-Davidson Motorcycles they left behind. One outstanding feature of ALL these letters is the way every man speaks of the stamina, power, and rugged dependability of his Harley-Davidson "sweetheart." And they look forward to the day when they can again thrill to the ownership of new Harley-Davidsons — motorcycles with greater performance than ever, made possible by the severe tests of wartime action.

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HARLEY-DAVIDSON MOTORCYCLES

Fort Busters

(Continued from page 202)

strongholds on the Channel coast, where the Dieppe raid showed painfully stiff resistance. Farther to the south, German engineers are known to be working feverishly to throw up and gouge out land blockades of ingenious types. And the northern exposure hasn't been neglected. Just how strong the Nazis have built their Northwest Wall along the coast of Norway is not known. But it's believed to match any of the Reich's fortifications, as is the belt of forts erected during the last year or so on Germany's eastern border and the Baltic coast.

Nazi engineers sidestep errors in construction that doomed Belgium's Eben Emael, France's Maginot Line, and the so-called indestructible forts of the Balkans and Greece. For instance, it is known that most of their forts may be evacuated easily, or may disgorge men and guns for mobile counterattacks. In the event of devastating frontal attack, they can shift reinforcements quickly from forts in the rear or to the side.

When the Germans reduced "impregnable" Eben Emael in seven hours with a handful of combat engineers and TNT, they set the pattern of destruction that soon may be used against them. For their enemies have improved the method to a point approaching perfection. For instance, one of the most effective weapons of the fort busters is an improved TNT charge. It's encased in steel, the same as the one which the Germans began using for the first time in 1940. But secret gadgets have greatly increased its blasting power.

The real pay-off, though, is the fact that the idea originally was as American as Brooklyn Bridge. In fact, it was a New Yorker, Prof. Charles E. Munroe, of Columbia University, who conceived it. He wrote about it in POPULAR SCIENCE MONTHLY in the year 1900. Eleven years later the Germans tried to tie up the idea with a patent, but somehow failed to do so. As an explosives expert, Professor Munroe discovered that a hollow charge of dynamite was many times more effective than a solid charge of the same weight. He experimented by simply draping a bunch of dynamite sticks around a can with open end out. Using nine pounds of dynamite, he blew a hole three inches in diameter through the five-inch steel walls of a safe. The charge the fort busters use weighs 10 pounds and can blow a hole two inches in diameter through 30 inches of steel-reinforced concrete. It's exploded by pulling a pin like that used in a hand grenade.

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In the heat of battle everywhere, on land, water and in the air, Champion-equipped engines add their roar to the thunder of our march to Victory. On the home front too, in a less spectacular way, Champion-equipped engines keep supply lines and transportation rolling with that characteristic dependability which is synonymous with the name Champion.

Spark plugs in today's high-output supercharged aircraft engines take a lot of **punishment. The same qualities that made Champion the spark plugs of racing champions have skyrocketed them to favor for our most powerful aircraft engines.**

Land battleships, with gas engines of greater size and power than those used by any other land vehicle, are most effective offensive and defensive weapons. Engines must not fail, and tanks with Champion-equipped engines are on every front.

"Handy Andy" of our armed forces everywhere, Champion Spark Plugs keep **plugging away through hell and high water in the majority of all jeeps.**

Patrolling our coastal waterways is an entire navy of smaller power boats. **Champion-equipped gas engines give them extreme speed and maneuverability.**

Cars, trucks, and buses, troop transports and commercial transports are all equally **vital to the war effort. Champion Spark Plugs are actively in the service here.**

Helicopters are destined to become a tremendously valuable defense against **submarines. Sikorsky Helicopters are equipped with dependable Champions.**

FOR NATIONAL SECURITY—FOR PERSONAL SECURITY—BUY WAR BONDS

It's Pop, the foreman. And is he mad! Like any good production head or conscientious mechanic, Pop knows what happens to a file when tossed among other files or tools. Even a few battered teeth can cause skips, throw the filing stroke out of stride—waste time—destroy accuracy—*reduce the efficiency and earning power of the worker.*

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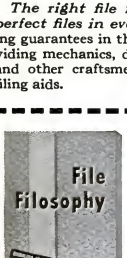
The right file for the job and *Twelve perfect files in every dozen* are long-standing guarantees in the Nicholson policy of providing mechanics, die makers, model builders and other craftsmen with the very best in filing aids.



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NICHOLSON FILES *FOR EVERY PURPOSE* NICHOLSON U.S.A. MADE IN U.S.A.

"Fork-Tailed Devil"

(Continued from page 100)

Minor changes in design were effected, and improvements suggested by actual use incorporated. It was not until September 1940 that the first actual production model rolled off the line. Some airmen, pointing out that the ship was heavier than a 10-passenger commercial transport plane, still thought it was a freak, with no real future as a fighter. The Army knew better, but took the wise decision to keep its husky baby under wraps until it had enough of them to deliver a solid punch.

The combination of power, clean aerodynamic design, and a quick-acting combat flap enables the P-38 to fly great distances and then battle on even terms with enemy interceptors hundreds of miles from its own base. The ship can take off and land at 80 miles per hour, fly faster than 400 m.p.h., climb to 40,000 feet, carry up to two tons of bombs for short distances, and outrun the speediest enemy if that becomes necessary.

That combat flap, developed when the Army called for increased maneuverability, increases the wings' lift substantially while increasing the drag only slightly. Thus the P-38 can roar to its objective at top speed, and in three seconds the pilot can lower the flaps to transform his ship into an acrobatic dogfighter, dive bomber, ground strafer, or precision bomber. After raising the flaps—time, four seconds—he can streak for home, then lower them again to land safely in snow, soft earth, or a rough field.

Although a heavy fighter, the Lightning apparently can be maneuvered in a fairly short radius, and has shown a surprising ability to climb on one engine even in combat with the vaunted lightweight Zero. Its propellers, driven by 1,325-hp. Allison engines, rotate in opposite directions, nullifying the torque and giving it equal maneuverability to either side. Pilots have taken advantage of that to blast many a Jap or Nazi flyer who could pull out of a dive only to the right because of torque.

Its high speed and altitude have made the Lightning invaluable upon occasion as a photographic reconnaissance ship. Stripped of armament, it can snap and run away in broad daylight. Painted dead black for night work, it can get into position for the run, pop flares, snap its pictures, and glide off like a dark cloud before the wind.

In this connection, it is an odd fact that the Lightning's first shooting encounter with the enemy occurred while the ship was unarmed. Capt. Karl Polifka was taking

(Continued on page 208)

but here is one worry you can avoid

TRANSPORTATION, *by any means,* is really a problem these days. Take your car, for instance. Because you drive it *less,* you have a different problem than if you drove it a lot.

For idle batteries run down—idle pistons and bearings can rust from water and sludge in the crankcase—scale and rust can ruin a radiator. And tires lose air just the same.

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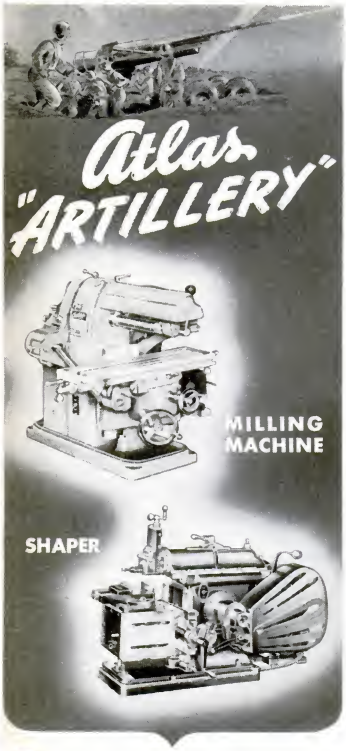
Your dealer checks every vital point of your car against his Marfak chart. No guesswork here . . . which means accurate protection for irreplaceable engine and chassis parts.

So insist on genuine Marfak Lubrication today—to keep your car in "top" condition for the important job it does for you and Uncle Sam. At Texaco and other good dealers everywhere.

Tune in the TEXACO STAR THEATRE every Sunday night. See your local newspaper for time and station.

You're Welcome at **TEXACO DEALERS**



As Allied forces move up for the victory campaigns, they'll be staunchly supported by Atlas "artillery" on the home front. Atlas Lathes, Milling Machines, Shapers, and Drill Presses are pouring a steady stream of precision-machined parts into the battle. In shipyards, on airfields, and in key industrial plants throughout the nation, these modern compact tools are favorites for fast, precision production. Remember after victory how Atlas accuracy and rugged strength have been proven in the toughest test of the ages. Atlas Press Company, 955 North Pitcher Street, Kalamazoo 13D, Mich.

BUY BONDS NOW - FOR A NEW Atlas SHOP AFTER THE WAR

"Fork-Tailed Devil"

(Continued from page 206)

pictures over Lae and Rabaul, New Guinea, when a flight of Zeros jumped him and knocked out his port engine in the first burst. Unable to fight back, Capt. Polifka climbed to 25,000 feet on the remaining engine, evaded the foe, and got home with photos which were officially credited with helping to win the Battle of the Coral Sea.

As fighters go, the P-38 is a big ship and a strong one. It can take a lot of gunfire punishment without crumpling, for its wings are double-skinned and its strength members double-stressed. If a wing is riddled, the spars can support the ship's weight; if a spar is severed, the skin itself has structural strength to hold together for the homeward flight.

No other fighter surpasses the P-38 in sustained fire power. It has various combinations of armament, a typical arrangement being four .50 caliber machine guns and a 20-millimeter automatic cannon, all concentrated in the nose, whence they can deliver an intense slash of steel and explosive. The pilot also can do a lot of shooting without a reload; the Lightning normally carries some five times the weight of guns and ammunition packed by lighter ships such as the Zero.

Most recent additions to the Lightning's equipment are combinations of extra gas tanks, smoke tanks, and bombs. The streamlined, droppable fuel tank of 150-gallon capacity enables the ship to protect bombers over a combat range of 750 miles and farther. Over shorter ranges, P-38's have carried as much as two tons of extra equipment, including medium-size bombs.

Extra range also has made the P-38 a handy ship for delivery to the war zones. Lightnings flown to the Aleutians gave the Japs a rude surprise early in the war. Hundreds of them have made mass flights across the North and South Atlantic. For such hops, each plane carries two extra 165-gallon fuel tanks, one under each wing. When the gasoline is used, the tanks are jettisoned. Since P-38 pilots have no time or equipment for navigation, a Flying Fortress accompanies each flight as "shepherd."

The P-38 is getting around in this war, and you may see it anywhere. If so, it will be an easy ship to spot from the ground—partly because of the forked tail that impressed the Germans so forcefully, and partly because of the front arrangement of wing, nose, and two engines, which gave it the airmen's poetic description of "three bullets on the edge of a sword."

EVEN THE GENERAL CHANGES HIS HAT

In time of action the leader must lay aside his trim hat, strip off his gold braid and sleek attire. He looks different—but his ability and character remain the same!... PLUMB, too, dons a "service uniform". Because of Government Limitations the appearance of some Plumb Tools has been changed. But the "hidden qualities" remain the same. Plumb Tools have the same hang and balance, design and temper that won them a quality reputation for nearly ninety years. While the fine finish has gone for the duration you will recognize Plumb design and balance by the ease and speed with which it works.... Plumb is proud of its service uniform! Fayette R. Plumb, Inc., Dept. M-5, 4957 James Street, Philadelphia, Penna.

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WILLIAMS
SUPERIOR DROP-FORGED TOOLS

Postwar Locomotives

(Continued from page 59)

perature is too hot to be used effectively on anything but a turbine, it is fortunate that the practicability of substituting a non-condensing steam turbine for the reciprocating engine of a coal-burning locomotive has been demonstrated by the "Turbomotive," built by the London, Midland, and Scottish Railway in 1935. This locomotive, known as "Gracie Fields" because "she sings as she goes," uses steam at a 250-pound pressure, superheated to 750 degrees, in a 2,000-hp. turbine geared to the front driving axle.

While the future of the noncondensing turbine-geared locomotive seems bright, it appears that the condensing steam locomotive, if it is to develop at all, will have to do so as a steam-turbo-electric machine. Outstanding example of this type of engine is the one built by General Electric in 1939. It comprises two 2,500-hp. units, with each unit carrying its own generating plant in the form of an oil-burning Babcock and Wilcox water-tube boiler, which furnishes superheated steam at 1,500-pound pressure and 920 degrees F. to a turbine driving a direct-current generator. There is no reason why similar locomotives should not be built to use powdered coal as fuel.

Because of its high thermal efficiency, which reduces fuel cost and permits long nonstop runs, the Diesel-electric locomotive promises to be the standard main-line engine of postwar service. The only rival that may threaten its position is the internal-combustion turbine locomotive with either an electric drive or hydraulic transmission. Chief problem of such an engine is producing metal that will withstand the high temperatures at which the engine must operate. However, an oil-burning gas turbo-electric locomotive is now in operation on the Swiss Federal Railways (P.S.M., May '43, p. 114).

The development of a reliable internal-combustion turbine raises the interesting possibility of combining the gas turbine with some form of gas producer that will give railroads operating in coal-burning districts an engine that will burn coal with an efficiency comparable to that with which Diesel-electric locomotives burn oil. Pioneering efforts have already been made by Brown, Boveri, & Co., builders of the Swiss engine, who have constructed a gas turbine that "burns" powdered coal from which gas is generated. The full development of such an engine, however, is not likely to take place soon enough to make possible its use in the immediate postwar era.

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● A nut is for just one purpose.

That is to fasten things together.

A good nut holds tight. It doesn't shake loose even under vibration.

This is the particular virtue of the Elastic Stop Nut.

This nut has an elastic red collar in the top. The collar grips the bolt and keeps the nut and bolt threads pressing tight against each other. There's no play. There's no wobble.

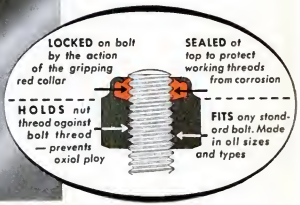
So the nut stays put.

It can be taken off and put back on and still lock. Anywhere on the bolt.

We've made billions of Elastic Stop Nuts.

They're on every airplane made in America. And on all kinds of war material.

And as far as we know, not one has ever failed to do its job surer and better than any other similar fastening.



Elastic Stop Nuts hold tight and make better electrical contact. Connections are safer and more efficient.

Youngsters' toys take a beating. They'll last longer and take less "fixing" when Elastic Stop Nuts are used.

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Lock fast to make things last

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If you could split a hair into fractions, you'd have a rough measure of tolerances allowed in Stevens' production of military rifles. Each part undergoes many tests with gauges capable of determining accuracy to the ten-thousandth of an inch.

PRECISION . . .

to a **fraction** *of a hair's breadth*

Production of military rifles requires technical knowledge and equipment capable of the most precise manufacture. And—these rifles must be turned out in tremendous quantities.

It was not a new experience for Stevens to produce "Quality in Quantity." Before the war Stevens was one of the largest producers of sporting arms. Yet the processes of manufacture followed a routine of painstaking precision that assured a high degree of safety, accuracy and reliability for all Stevens products.

When the war is over . . . you can count on Stevens to offer sporting rifles and shotguns that will represent greater values than ever before.

J. STEVENS ARMS COMPANY
Division of Savage Arms Corporation
Chicopee Falls, Mass.

STEVENS

Flying Gun Carriers

(Continued from page 86)

sion is now the standard British aircraft machine gun.

But U. S. airmen now favor the larger Browning .50 caliber air-cooled gun, and say flatly that it is the finest large-caliber aircraft machine gun in the world. Weighing less than three times as much as its little brother, it throws four times as much lead per second, and throws it with a heavier punch. The muzzle velocity of its 800-grain (nine to the pound) bullets is 2,900 feet a second, and after they have traveled 1,800 feet in less than three quarters of a second they still have a striking velocity of 1,950 feet compared with the .30 caliber's 1,500 feet. The .50's rate of fire ranges from 700 to 850 shots a minute, depending on whether it is firing free or is slowed down by synchronization with the propeller.

A synchronized Browning is fired by a mechanical trigger motor attached to its receiver and connected through a solenoid and semiflexible tube with an impulse generator which is part of the airplane engine. This is really a form of high-speed semi-automatic fire, since the trigger motor actuates the trigger for each shot. This device, produced by Army Air Force engineers, is a vast improvement over the often unreliable hydraulic, rocker, and flexible-shaft synchronizers used in 1918.

Nevertheless, modern practice tends increasingly toward the use of wing guns to avoid any synchronizer and to take advantage of the gun's full rate of fire. The wing-mounted gun is fired by a remote-controlled solenoid, and continues to fire as long as the trigger is depressed and the ammunition holds out. Occasional trouble with belt-fed ammunition has been eliminated by the U. S. development of a disintegrating metallic-link belt. Each cartridge, acting as a pin, joins two metal links. When an empty cartridge case is extracted and ejected, the empty links that held it to the rest of the belt fall apart and tumble out with it.

The development of more efficient armor naturally stimulated the demand for harder-hitting guns. The United States was well abreast of the trend and by the time the present war started had an excellent 37-mm. cannon ready for production. This gun, with a bore of about 1½ inches, is recoil-operated and fires 1¾-pound high-explosive shells at a rate of 125 to 150 a minute. The shells have supersensitive nose fuses which will burst the charge on contact with the lightest airplane fabric. Armor-piercing shells of about two pounds also are fired.

The 37 is particularly effective as a tank buster on ground sweeps. It does have a limitation, however, in the amount of this fairly heavy ammunition that a fighter plane can carry on one sortie. For this reason, while some of our Lightnings and Airacobras mount the 37, others are being equipped with our version of the 20-mm. Hispano cannon. In either case, the heavy gun is supplemented with various combinations of .50 caliber guns.

R.A.F. officers long pinned special faith to increased numbers of machine guns, and tried out a fighter carrying 12 rifle-caliber guns, but they have now swung over to the heavier-caliber idea, and are using their own form of the Hispano 20.

The art of aircraft gunnery also has come a long way in recent years, and improved sights have given pilots an effective range of around 1,000 yards with 20 or 37-mm. cannon, and 300 yards with .50 caliber machine guns. For the present, however, the fighter pilot's own skill, reflexes, and "feel" of his plane and guns will count for more than any mechanical device.

For the gunners manning flexible defensive machine guns in a bomber, however, computing sights are invaluable. One of these devices includes an arrangement by which the gunner tracks the enemy plane and fires when it is framed in the sight. The gadget computes the angle at which the gun must lead the target, and corrects the aim automatically.

Since a Flying Fortress or Liberator may carry a dozen or so defensive guns, it is easy to see why these big ships have been so deadly to fighter planes venturing into the area of fire to attack them. Another ingenious device is the fire interrupter, which enables a gunner to fire without worrying about damaging the tail, elevator surfaces, or other parts of his own plane. This works either by guiding the gun's line of fire over or under the exposed part, or by interrupting the firing mechanism just as the gun swings into line with it.

Power-driven gun turrets appeared about 10 years ago, and are now used on many large bombers. The Flying Fortress, for example, has two hydraulic-electric turrets, operated by gunners who ride in them; some British heavy bombers have four.

Developments beyond that point are generally veiled in military secrecy, but it requires no great leap of the imagination to envision future battleships of the air in which multiple power turrets, covering every angle of attack, will be operated possibly from a protected central fire-control position like that of a surface warship, and a new chapter will open in the history of aerial fire power.

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Will you come along?

you bet you will

IT'S EARLY on an autumn morning sometime after Victory. A couple of your neighbors stop at your door. Dew shines on their boots. Their guns gleam, and you hear the muffled click of shells in their pockets as they move. They grin. You grin. "Ready?" they ask. "Right with you," you say. You slip into your jacket . . . you pick up your new H&R gun—the gun you've always dreamed of, well-balanced, beautifully finished, a top-notch performer in every way . . . and you're off on the hunt . . .

UNTIL THE WAR IS WON, all of Harrington & Richardson's guncrafting will continue to center on war weapons—principally the famous H&R Reising Submachine Gun.

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We intend to acquire patents or patentable ideas for new electrical or mechanical toys or specialties marketable under our brand name and through our well established channels of distribution.

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ADDRESS

THE PRESIDENT

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Your Home . . . Tomorrow

(Continued from page 79)

Towel bars will be warmed to dry towels, unless a new and satisfactory substitute is found in paper bath towels. In the bathroom, too, concealed ultraviolet-ray units will go on and off while you are shaving or bathing. Soap dishes will be designed to drain off water, or all our soap for use in the home may come in liquid form. Hand faucets will give way to flush, buttonlike controls, or floor pedals. Clocks and bath scales, as well as properly lighted dressing tables, will be standard equipment.

Your closets will be designed with a particular functional purpose and with care to make the maximum use of every cubic inch. They will, of course, be purchased as complete units. Throughout your house, devices of all kinds will be built into walls to free space for easier movement.

Laundry machines will wash, rinse, dry, and sterilize clothes in one continuous operation; and machine ironing, much improved, will become more common.

Your house of tomorrow will be so flexible that it will be capable of being adapted at short notice and small cost to the changing needs of your family. Extra rooms may be added at a fraction of the cost of such additions today. Within the shell of the house, partitions may be changed to new locations in a few hours.

Tomorrow's house will be able to spread itself horizontally, too, for it will not be limited by the edges of the present 40-foot city lot. Express highways and high-speed transportation will make it possible for people to live in ever-widening circles from urban centers, and will make the narrow city house plot obsolete. You will build your house tomorrow on a larger plot of ground, with lower property tax, at no greater time-distance from your work. With more space to spread out, houses will be built around play areas. You'll get into the sun more, and the sun will get into you more.

Planned as an economical unit, your house of tomorrow will cut down home living costs, decrease housekeeping labors, and reduce the family's doctor bills. Through radio and television it will become more a part of the outside world. But modern engineering will have made it more than ever before a man's castle.

Subscribers in the armed services who notify us of change of address are requested to give us the key symbols appearing on the wrapper in which the magazine is received.

Dear Bud:

You'd get a kick out of being in this outfit. It's a great gang! Most of 'em never rode a motorcycle before, but they're all fans for life now.

Hill climbs are tame stuff compared to the run over this operations course, but most of the boys are riding Indians and that's a machine built to take it. They all say Indian's dependability and easy handling give them a real feeling of confidence and safety. And by the way, wait till you see the improvements Indian will bring out after the war. Wow!

INDIAN MOTOCYCLE COMPANY, SPRINGFIELD, MASS.

Indian

BUY WAR BONDS NOW
★ ★ TO BUY AN INDIAN LATER ★ ★

● Ever wear one of those old-time bathing suits? They covered the subject well, but they wouldn't do today. There's been a big change.

An important change has taken place in tapered roller bearings, too! Heavier loads—tougher going—longer hours . . . all begged for a bearing with more rollers, to stand up better under sterner work. Tyson developed just that kind of a bearing.

More rollers, yes—Tyson has *thirty percent* more, on the average. Size for size, Tyson users get greatly increased load capacities. What's more important, they get almost doubled bearing life.

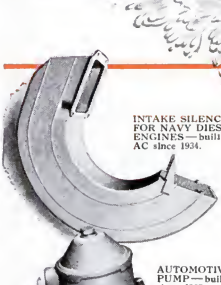
Tyson "All-Rolls" Bearings are in tune with the times. They're tough. They're longer-lived. They carry greater loads. The big name in bearings today is . . . TYSON!

TYSON BEARING CORPORATION, MASSILLON, OHIO

COUNT THE ROLLS · THE ROLLS COUNT

Tyson

TODAY'S HEAVY-DUTY BEARING



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AUTOMOTIVE FUEL PUMP—built by AC since 1927.

HUSH HUSH *for Sea Horsepower*

SEA-GOING diesel engines breathe with a constant roar. Transmitted through the intake system, this racket would be hard on engine-room crews. So, many of the diesels of our Navy are hushed by special AC intake silencers.

No adjustments are possible. Silencers must be *right* when they leave the AC production line. So, accurate, painstaking workmanship is demanded.

In spite of all this, Navy thoroughness requires regular checks on silencers—to keep them up to standard.

Your Fuel Pump, too, Needs Attention

The fuel pump on your car, truck, or tractor is blood brother to this silencer in its need for occasional care. Because it is precision built, it, too, gives trouble very seldom. But, its life can be definitely prolonged—and your transportation protected—if you will have your service man check your pump after thirty thousand miles of use.

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When replacement becomes necessary, select AC—for complete satisfaction.

Awarded to the men and women of AC on September 2, 1942, for outstanding achievement in producing for Victory.

AC SPARK PLUG DIVISION
GENERAL MOTORS CORPORATION

AC SPARK PLUGS

SPARK PLUGS—Dirty or worn plugs waste as much gas as one coupon in ten. Oxide coating collects on the plugs and causes them to misfire,—especially when the engine is working hard. Dirty plugs also cause hard starting which weakens your battery. Under present slow driving conditions, have your plugs cleaned and adjusted every few months.

AIR CLEANERS—A dirty air cleaner increases gasoline consumption because it chokes down the flow of air into the carburetor. Your air cleaner should be rinsed whenever your car is lubricated.

FUEL PUMPS—Practically trouble free. But, if yours has been in use thirty or forty thousand miles, it may be worn to the point where a check-up is due.

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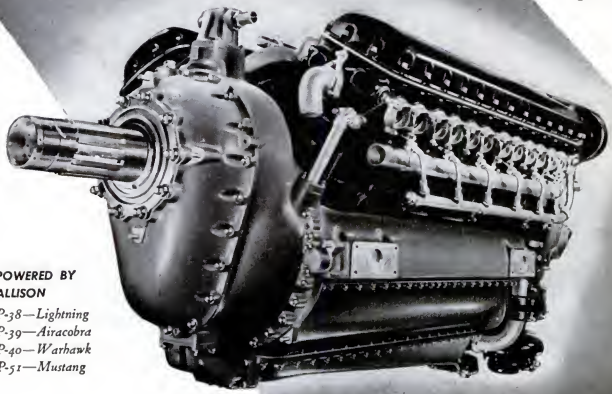

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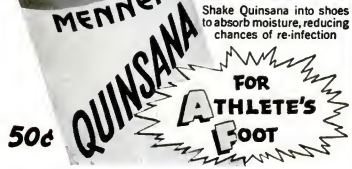

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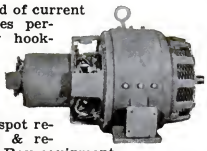

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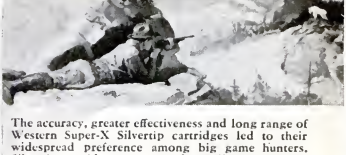

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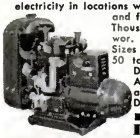

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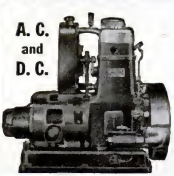

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